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R-E EXCLUSIVE!

PICTURE PHONE

Build the Picture Phone and you can use your telephone to send and receive live television pictures to and from almost anywhere. The first part of this series explains how the system works.

Part 1

THE TELEPHONE COMPANY has recently been urging us to "reach out and touch someone." The Picture Phone described here will allow you to do more than that—it permits still video-pictures to be sent over ordinary phone lines so you can not only hear and "touch" someone, but also *see* him (or her).

What do you need to send and receive pictures using the telephone? The most important piece of equipment, of course, is the Picture Phone. It turns an ordinary video signal into a series of audio tones that the telephone equipment can handle and convey to a Picture Phone at the other end of the line. It also converts incoming video—in the form of tones—into a fast-scan video signal that can be viewed on a monitor or TV receiver. Fast-scan and slow-scan standards are compared in Table 1.

A video camera is necessary (there's an exception to that, which we'll get to in a moment), but it need not be elaborate or expensive. A camera of the type used in closed-circuit applications will do the job and can be purchased for about $150. Of course, if you already own a color or black-and-white video camera, you can use that.

TABLE 1

	FSTV	SSTV
Line rate—lines/second	15,750	15
Frame rate—frames/second	30	⅛
Aspect ratio	4:3	1:1
Lines transmitted	525	128
Lines displayed	525	256

The picture can be viewed on a video

monitor or on a TV receiver fitted with an inexpensive RF-modulator that will convert the composite-video signal into one that can be received on an unused VHF or UHF TV-channel.

You'll also probably need a device from your local phone company to couple the Picture Phone to their lines.

The exception to the video-camera rule is due to the fact that, since what is being transmitted is a series of audio tones, none higher in frequency than 2300 Hz, pictures can be recorded on a standard audio-cassette. If you know what you want to send, and can borrow a camera, the pictures can be put on tape ahead of time and the tape played when you're ready. Pictures received via the Picture Phone can also be saved on cassette for future reference.

Oh yes, you'll need a telephone, too.

How it's used

How do you carry on a video conversation using the Picture Phone? You start out just as you would any telephone conversation, speaking with the party at the other end of the line.

When the time comes, though, to illustrate a point (or, perhaps, to show off a brand new addition to the family) you turn the MODE switch to TRANSMIT, push the VIDEO button, and a picture will be transmitted to the Picture Phone at the other end of the line. The picture can be "set up" ahead of time and stored in the Picture Phone's memory or can be transmitted "live." The same frame can be repeated over and over or a new one can be "snatched" and sent every eight seconds. As you become more familiar with them, the capabilities of the Picture Phone will prove it to be an extremely versatile instrument.

At the other end, when video is ready to be received, the MODE switch is put into the RECEIVE position, the VIDEO button depressed, and, over a period of eight seconds, a still picture will appear from top to bottom on the screen of the monitor or TV set. The picture can be stored in the Picture Phone's memory and viewed even after the transmission is over and you are back in the VOICE mode. As was mentioned earlier, the pictures can be stored on audio cassettes for replay later.

The system used by the Picture Phone is described elsewhere in this article but, before we present instructions for building the device, we'll describe in some detail how it works. Not only will that help you to understand what's going on, but you will also receive something of an education in how digital circuitry works.

In must be mentioned that the construction of this project is *not* for beginners—the circuit uses nearly 100 IC's on a tightly packed double-sided PC board—but for those with previous construction experience, it should not prove difficult. Assembly is straightforward, and troubleshooting hints will be presented. Before we get to that, though, let's see what's needed to make the Picture Phone system function, and look at the circuit section by section.

Signal conditioning

Refer to Figs. 1 and 2 as we discuss how the Picture Phone operates. Signals from a fast-scan source such as a video camera or VCR are applied to J8, CAMERA IN. The signals are attenuated by R305 and AC-coupled to the video-input amplifier. DC bias is added to the signal by R307.

The video-input amplifier consists of transistors Q4 and Q5. Its first stage has a gain of 10 and its second stage is an emitter follower whose low output-impedance drives the A/D converter.

Slow-scan signals (see box copy) are input through either the TAPE IN jack, J6, or from the telephone line. The incoming signal drives a limiter made from op-amp IC90-b. Following that limiter are two active bandpass filters with full-wave rectifiers at their outputs. The output of the rectifier is combined by IC91-b. That filter/rectifier/combiner network forms a tuned FM-discriminator having an "S"-shaped transfer function. Modulation ripple is removed from the demodulated FM by a 4-pole Butterworth low-pass filter made from sections of IC92 and IC93.

The recovered slow-scan video is then attenuated by R313 and DC-biased by R323. From there it is fed to the same amplifier used for fast scan. A section of switch

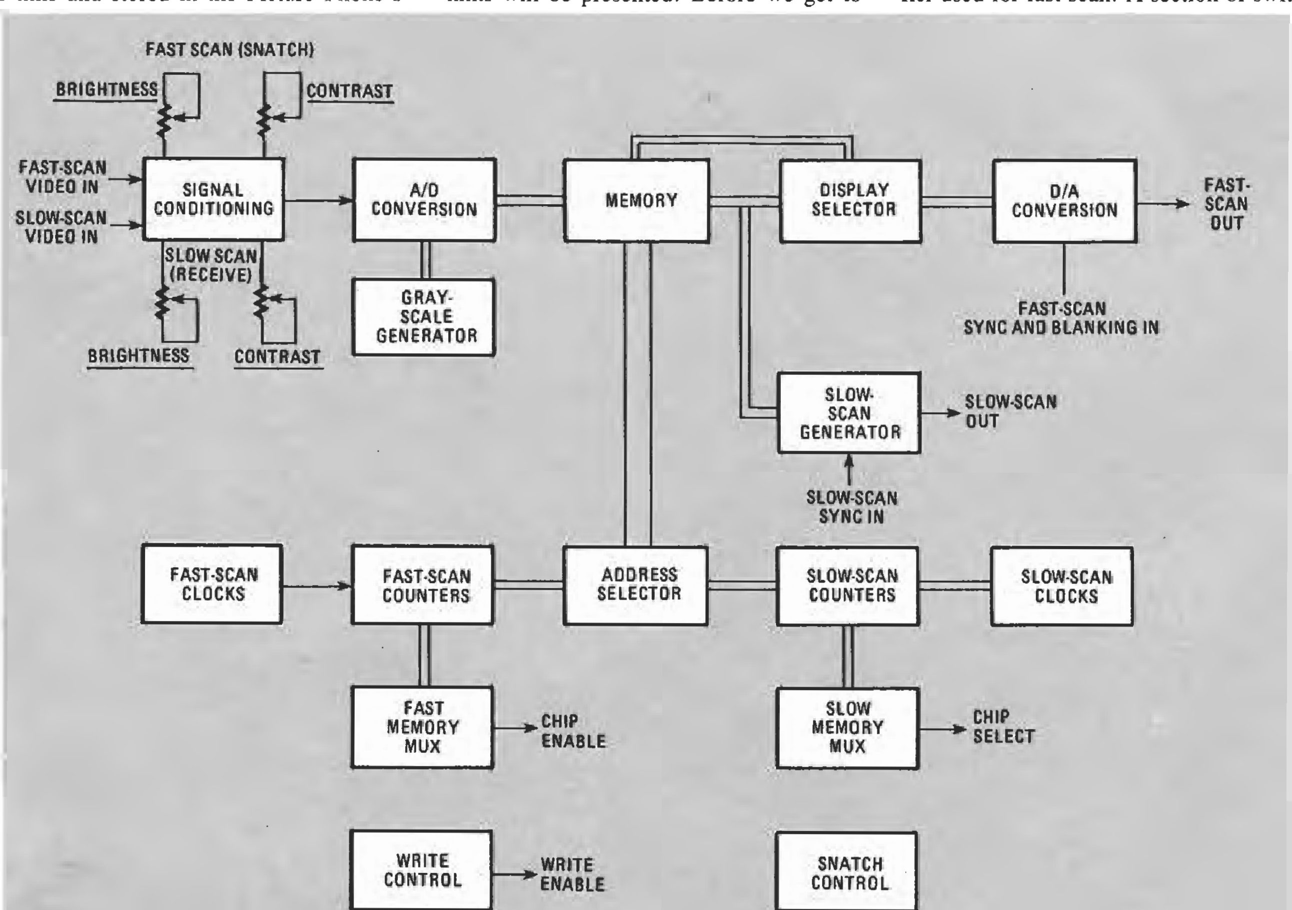


FIG. 1—LOGIC AND TIMING portions of Picture Phone circuit are shown at bottom of block diagram; video-processing blocks are at top.

HISTORY OF SSTV

Slow-scan television (SSTV) was developed during the 1960's by amateur radio operators to allow them to send pictures within the narrow (3-kHz) bandwidth permitted them by the FCC for transmissions on frequencies below 440 MHz.

Fast-scan television—the kind you're accustomed to watching in your living room—uses a bandwidth of about four *MHz*, so SSTV required a completely different technique to meet its restrictions.

SSTV uses a frame consisting of 128 lines, instead of the 525 used commercially. The horizontal-line rate is 1/15 of a second (as opposed to 1/15,734-second for fast scan), which means that it takes eight seconds to send—or receive—one slow-scan picture.

Audio tones are used to send the video and sync information—SSTV is frequency-modulated, unlike fast-scan TV, which is amplitude modulated. A frequency of 2300 Hz represents white, 1500-Hz represents black, and 1200-Hz is used for sync.

In the early days of SSTV, the output of a fast-scan camera was sampled over a period of eight seconds and converted into the tones required to transmit the video over the air. That means that, if a live subject was used, he had to sit still for that length of time.

At the receiving end, the image was viewed on a P7 (long-persistence) phosphor CRT of the sort used in radar displays. The picture started at the top and, eight seconds later, finished at the bottom. The top portion of the CRT was still glowing faintly at that point, and picture could be made out. There was no easy way, though to keep the image on the screen after it had been sent, so a lot of imagination was required.

The first scan converters were analog.

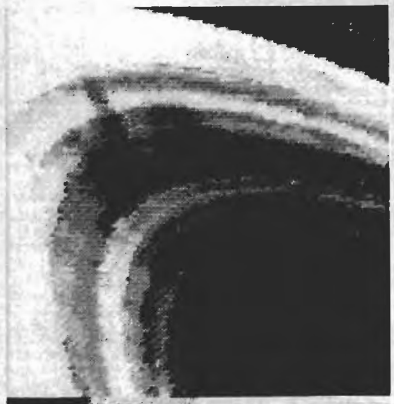


FIG. 1

They used surplus (blemished) video storage-tubes that, if new and perfect, would have cost about $50,000. With them, fast-scan video could be written onto the tube quickly and read out slowly, meaning that you could "snatch" a fast-scan picture in a 60th of a second and then read it out slowly for slow-scan conversion. Similarly, a slow-scan picture could be received and written onto the surface inside the storage tube and then read out quickly—and repeatedly. That allowed the image to be reproduced on a black-and-white monitor or TV set and viewed until all the details had been absorbed.

In the second half of the 1970's another technique for scan conversion was developed using digital IC's to store the video information. One of the earliest used 64 shift registers going around and around to store the data. Current scan converters, like the one described in this article, use RAM (*R*andom-*A*ccess *M*emory) IC's—the same sort used in computers—to hold the data representing the picture.

One of the most impressive uses of SSTV has been made by the Jet Propulsion Laboratories Radio Club, W6VIO, in Pasadena, CA. During the Viking missions to Mars, and the Voyager space probe encounters with the outer planets, the club station has retransmitted pictures from space on SSTV to amateur radio operators all over the world. (Figure 1 shows a view of Saturn's rings. The "spokes" can be clearly seen.) Many of those pictures were seen before they were reproduced on television or in the papers, and some of the material that was sent never even made it to the media.

Your use for SSTV will probably be more mundane (pun intended). The audio frequencies used for slow scan fit nicely into the bandwidth that can be carried on an ordinary telephone line, which means that you do not need radio equipment to send or receive pictures—you can do it by telephone.

For a number of years the Bell System has offered a very limited *Picturephone* service, which requires that you go to a special center—one of a very few, and only in large cities—to see and talk with someone at another similarly equipped center. That service is not cheap, and, as you can imagine, it has not been too convenient, either.

Now, using SSTV, you can exchange video with anyone, anywhere, as long as you both have a telephone. You can transmit and receive pictures for business—of the people involved in long-distance negotiations, for example, or of portions of schematics, charts, or photographs that might take days to get from coast to coast by conventional means.

On a more personal note, you can chat with—and see—far-away friends and family whenever you like. All you need is a telephone, TV camera, and the Picture Phone. What's more, slow-scan video, because it's transmitted as a series of tones, can be stored on an ordinary audio cassette and replayed whenever you like. Top that, Ma Bell! **R-E**

S2 selects either fast- or slow-scan video for input to the memory.

Slow-scan sync signals are derived from the composite slow-scan signal by a low-pass filter made from IC93-b. An automatic-threshold sync separator, Q1, strips the sync from the video. Horizontal and vertical sync signals are separately filtered by non-linear filters Q3 and Q2. The filtered sync signals are converted to fast-rise-time logic signals by Schmitt trigger IC63. (The legend "ESH" stands for *E*xternal *S*low-scan *H*orizontal sync, and "ESV" for *E*xternal *S*low-scan *V*ertical sync. A bar above the legend indicates that the signal goes to a logic-low state when sync is present.)

Fast-scan sync is derived from the input video by automatic-threshold sync separator Q7. The horizontal and vertical sync signals are separated by the differentiator/integrator formed by Q8 and Q9. The sync signals are inverted and buffered by IC61-c and IC61-d. (The legend "EFV" stands for *E*xternal *F*ast-scan *V*ertical sync and "EFH" for *E*xternal *F*ast-scan *H*orizontal sync.)

A/D conversion

The analog video signal is continuously digitized into a series of 4-bit nybbles (half-bytes). A 4-bit nybble can represent 16 shades of gray, which has been found to be sufficient to display an intelligible black-and-white image without either using excessive memory, as would be the case if a larger word-size were used, or inducing excessive contouring (abrupt transitions from one gray-shade to the next), as would be the case if a smaller word-size were used.

A voltage divider (R60-R75) with equally-spaced taps establishes the 16 amplitude levels representing the gray shades. Each tap is connected to a comparator (IC73-IC80), that outputs a signal indicating whether the amplitude (gray shade) of the video at its position is greater or less than that established by the voltage-divider chain.

The comparator outputs are combined by logic gates IC88 and IC57-a and IC57-b to form a 4-bit nybble representing the instantaneous luminance value of the video signal. The whole forms what's known as a *flash converter*.

This type of A/D conversion has certain disadvantages, namely that the transition from one gray shade to another may involve changing the state of more than one bit of the 4-bit nybble. If several bits change at once, voltage spikes may occur, and be read as part of the video data. To avoid that, before the data is entered into memory it is converted from a straight binary number into one expressed in Gray code. In the Gray code, it is possible to go from any 4-bit value to the next one without changing more than a single bit, which tends to eliminate the glitches we want to avoid. Binary-to-Gray code conversion is shown in Table 2.

Memory

The heart of the digital scan-converter is its memory. It consists of 16 μPD411D (MM5280) 4K × 1 dynamic RAM's. (See Fig. 3) The memory is organized so the LSB (*L*east *S*ignificant *B*it) of each nybble is stored in IC1-IC4. Higher-order bits are stored in succeeding rows in the same order as they occur in the nybble. The memory is

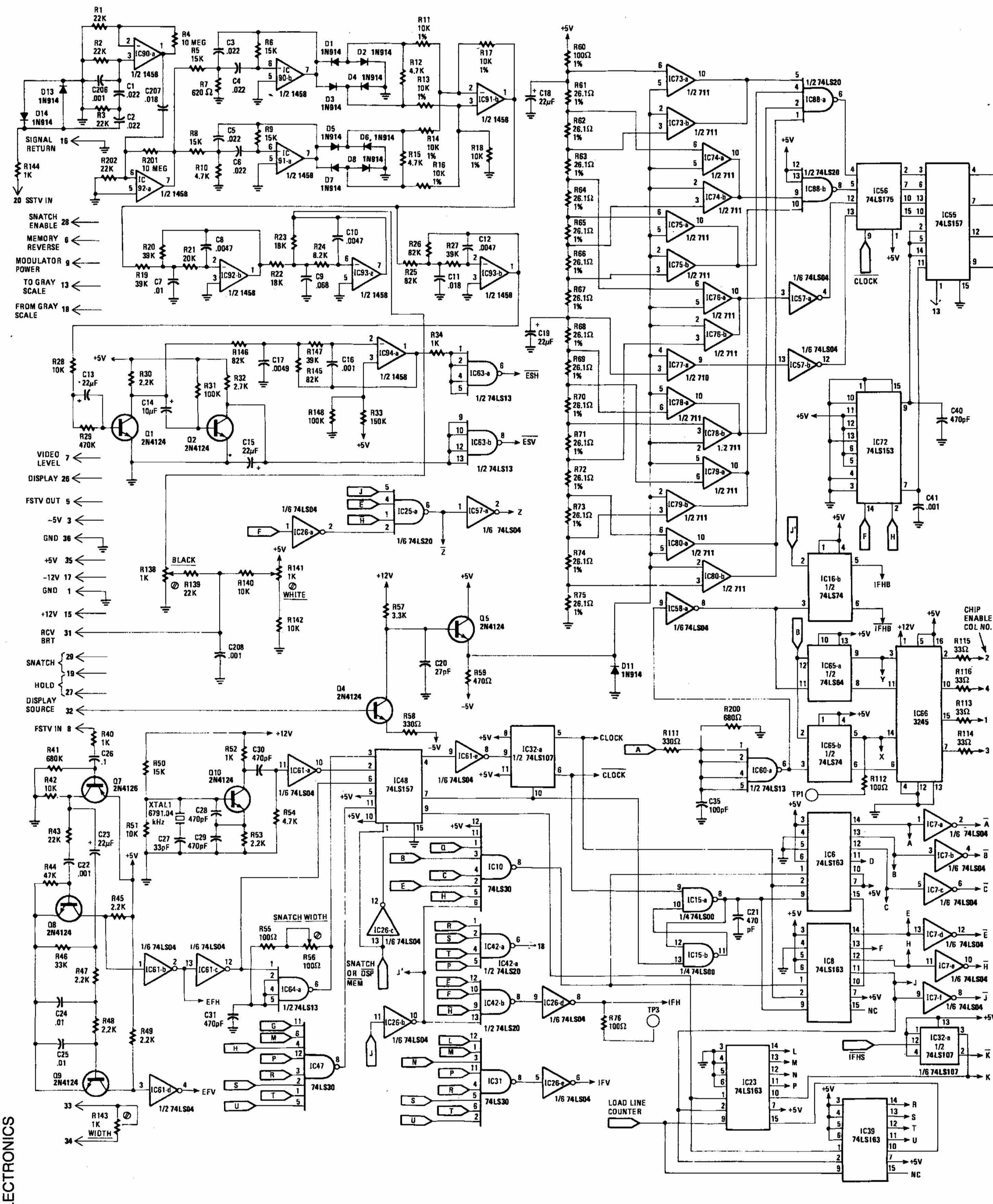
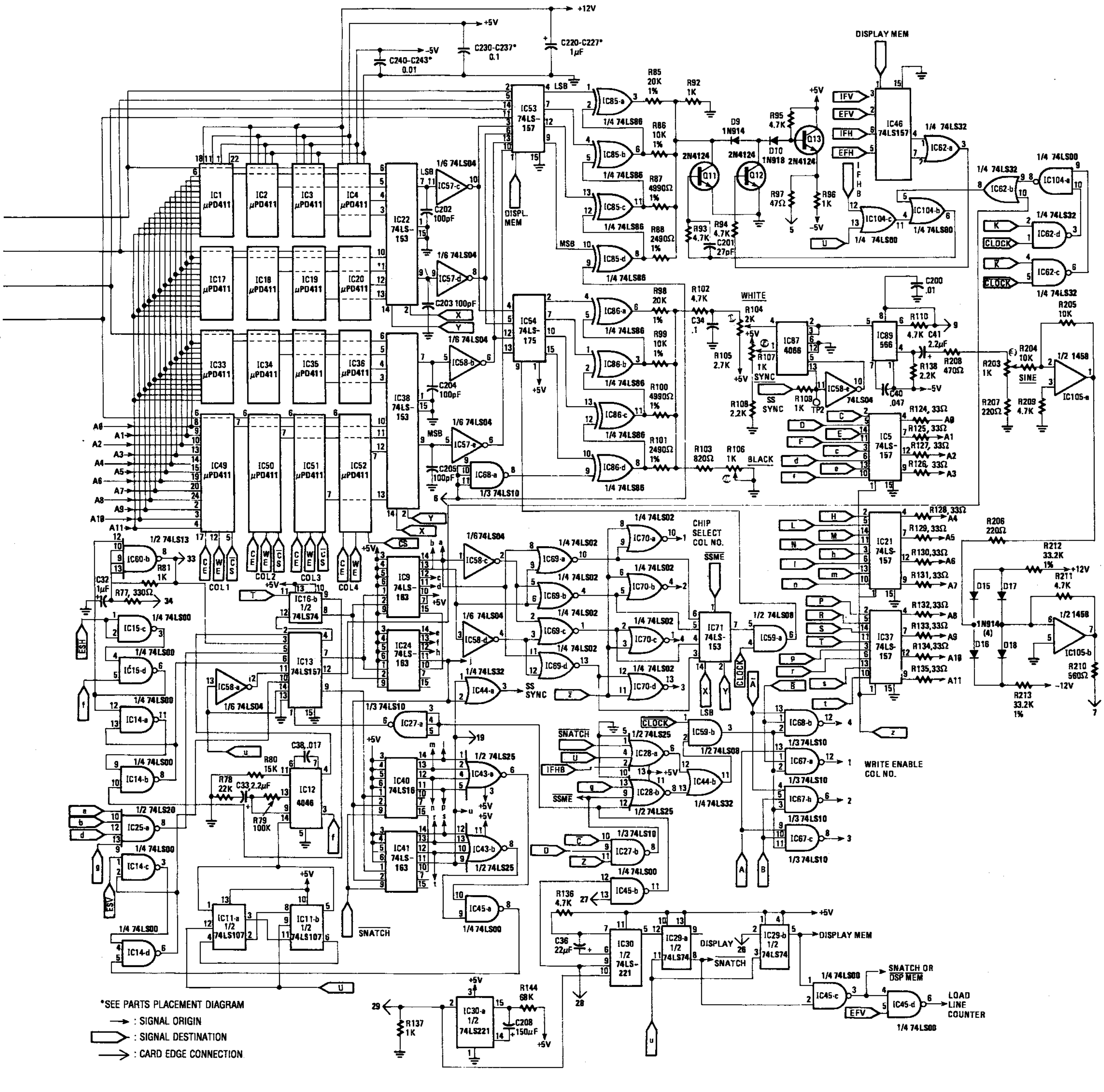


FIG. 2—HEART OF THE PICTUREPHONE is its memory, sixteen 4K-bit IC's that store video information prior to scan conversion.


*SEE PARTS PLACEMENT DIAGRAM
: SIGNAL ORIGIN
: SIGNAL DESTINATION
: CARD EDGE CONNECTION

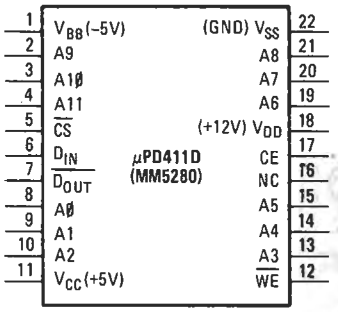


FIG. 3—PINOUT OF MEMORY IC shows destination of some of the signals generated by the Picture Phone's clocking and logic circuits.

TABLE 2

Shade	Binary code	Gray code
White	0000*	0000*
	0001	0001
	0010	0011
	0011	0010
	0100	0110
	0101*	0111*
	0110	0101
	0111	0100
	1000	1100
	1001	1101
	1010*	1111*
	1011	1110
	1100	1010
	1101	1011
	1110	1001
Black	1111*	1000*

* Values used for gray scale

multiplexed to increase its speed by operating IC1, IC2, IC3, and IC4 (and back to IC1) in overlapping fashion. Thus the active IC's shift from column to column as the picture goes from pixel to pixel. Memory organization is shown in Fig. 4.

Memory shifting is determined by the CE (Chip *E*nable) signal, which will be discussed later. As the memory shifts, it is necessary to shift the output from column to column. That is done by IC22 and IC38—double-pole, 4-throw multiplexers. Input signals to memory are connected in parallel to each IC in any given row.

The memory-control signals are CE, WE (*W*rite *E*nable) and CS (*C*hip *S*elect). The CE signal carries the clocking information. The WE signal controls whether information will be fed into a memory IC, or read from it, depending on whether it is a logic-high or logic-low. The CS signal determines whether an IC is available for data transfer or not.

In the Picture Phone, the CE signal acts as both the memory clock and as the source of the fast-scan memory multiplexing. Slow-scan multiplexing takes place according to the state of the CS signal.

Display selector

A 4-pole, double-throw multiplexer, IC55, determines whether the video monitor will display the picture stored in memory or the live (digitized) picture from the video source. The selection of the live or stored picture is made by S2.

D/A conversion

Before the digitized video can be converted back to an analog signal for viewing, it must be converted from gray-scale values back to standard binary ones. That conversion is performed by IC85, a 4-section EXCLUSIVE OR gate. By controlling the logic state of one of the inputs of that EXLCUSIVE OR gate, inverted video (a negative image) can be produced.

Weighting resistors connected to the outputs of IC85 generate a voltage proportional to the value of the 4-bit binary word applied to its inputs. Emitter follower Q13 provides a low output-impedance to drive the video monitor. Sync and blanking signals are combined with the raw video by voltage shifting produced by transistors Q11 and Q12.

Slow-scan generator

In this section, slow-scan picture information read from memory is latched, code-converted, converted from digital to analog form, and used to frequency modulate an oscillator.

At the end of each fast-scan line (every 63 microseconds) the memory-address lines are connected to the slow-scan address counter long enought to read one slow-scan pixel. That piece of the slow-scan picture, still in digital form, is latched by IC54 and held until new information is available. Slow-scan pixels occur at a rate such that a new one is available every 500 microseconds. At the 63-microsecond rate, each pixel is read about nine times. That re-reading does not affect performance in any way.

The latched information is converted from Gray to binary code by IC86 by the same process that was used for the fast-scan information. The same control signal that was used for black-to-white picture reversal in the fast-scan section is used for that purpose here. Because of the difference in picture polarity between fast and slow scan, an inverter, IC68, is used in the polarity control-line. Resistors R98-R101, as well as R103 and R106, are used for the digital-to-analog conversion.

An electronic analog-switch, IC87, is used to select either slow-scan video or a DC sync-signal level for input to the FM oscillator, IC89. The operation of that switch is triggered by the horizontal and vertical sync-pulses.

The FM oscillator, IC89, generates an audio-frequency triangle wave. That triangle wave is later converted to a sine wave by IC104. The amplitude of the slow-scan audio is controlled by R203.

Fast-scan clocks

All scan-conversion operations that do not require the fast-scan camera are controlled by clock signals derived from XTAL1, a 6791.04-kHz crystal. Transistor Q6 is the oscillator, and a section of IC61 acts as a buffer.

Operations that use the fast-scan camera use a free-running oscillator synchronized with the camera's horizontal-sync pulses. A synchronized oscillator avoids the horizontal jitter of pixels that would take place if an asynchronous clock were used. The synchronous oscillator is a section of IC64. The SNATCH WIDTH trimmer potentiometer, R56, controls the oscillator frequency so that the camera and memory displays will have the same width.

A 4PDT multiplexer, IC48, selects either the crystal- or synchronous-oscillator. The latter is used to "snatch" a field of fast-scan video and for the camera display; the output from the crystal-controlled oscillator is used at all other times.

The clock oscillators operate at 6.791 MHz—twice the frequency of the system clock. Flip-flop IC32 divides the output of the oscillator by two to obtain the actual clock pulse-string, which assures perfect symmetry of the waveform.

When we continue this article, we'll conclude our discussion of how the Picture Phone works. We'll also look at the power supply for the unit, the telephone interface circuit, and, space permitting, begin our discussion of how to build and align the device. **R-E**

Due to space restrictions, and the necessity for a lengthy technical discussion of the Picturephone circuitry, the parts list and foil patterns for the device will be presented in a future part of this article. The wait will be worth it.

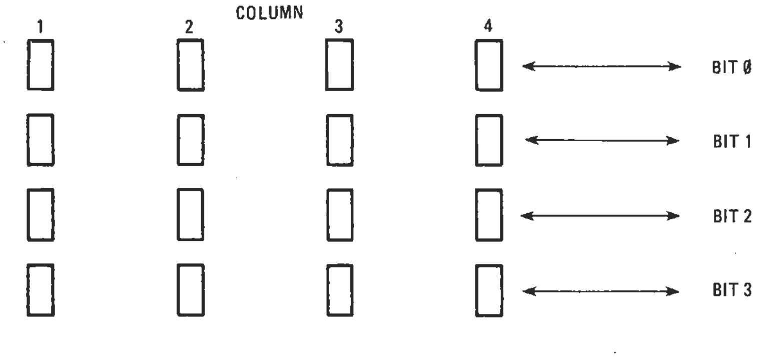


FIG. 4—MEMORY IC columns are multiplexed to provide speed needed for fast-scan applications.

Picture Phone

Before you build your Picture Phone, you should know how the device works. We'll conclude our discussion of that topic in this part.

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Part 2 THE FIRST PART OF THIS article discussed the theory of operation of a good portion of the main board of the Picture Phone. We'll now complete that discussion; it will be helpful if you have Part 1 handy.

Fast-scan counters

The fast-scan counters are IC6, IC8, IC23 and IC39. Each IC is a four-stage binary counter that is cleared to all zeroes when pin 1 is taken to a logic-low state. When pin 9 is low, the counter stages are preset to the value hard-wired at pins 3-6. Pin 2 receives the clock pulses, and responds to their positive-going edges. Both clear and load operations are synchronous—that is, they take place only on the positive-going edge of the clock pulse. When the LOAD or CLEAR pin is taken low, the counter stops and retains its value. If a clock pulse occurs while the appropriate pin is low, the counter will load or clear.

The fast-scan dot counters are IC6 and IC8 (dots are the pixels along a line of video). The dot counter is analogous to the horizontal sweep in the camera and display. The dot counters have two modes, one for the camera and one for all other operations.

Let's consider non-camera operation first. The crystal oscillator supplies clock pulses to pin 2 of the dot counters. Note that pin 15 of IC6 is connected to pin 10 of IC8. That is the "carry" from the first IC to the second, and provides synchronous operation of both IC's.

Figure 5 shows the timing of the dot counters. The counter CLEAR pulse is provided by IC10 at a count of 215. That means that the counter advances to 215, is reset to zero, and begins to count again. The internal horizontal-sync pulse (IFH) is produced by counter inputs applied to IC42. The clock frequency, divided by 216 (the count from zero to 215), generates the correct horizontal-sync frequency.

Signal "J," which is low between the counts of zero and 127, serves several purposes. It is delayed by one clock pulse to form IFHB, the internal fast-scan blanking signal, which blanks the display in all modes. That signal is also applied to IC28 to control when data can be written to memory. Memory-write takes place, and the display is unblanked, when the counter is between zero and 127.

Now let's look at the operation of the dot counter in the "snatch" and camera-display modes. The clocking signal is derived from the synchronous oscillator; and IC10, which supplies the CLEAR pulse, is disabled. The counter advances until a horizontal-sync pulse from the camera (EFH) takes the LOAD pin low. The counter is preset to a value of 217, as determined by the fixed inputs to pins 3-6 of IC6 and IC8. The counter resumes counting at a preset value of 217 when EFH is no longer present. When it reaches its maximum count of 255, it resets to zero and starts counting again. The time spent counting from 217 to 255 represents blanking of the left-hand edge of the picture; the time between 128 and EFH is used for right-hand blanking.

The LOAD pin is controlled by an RS flip-flop made from IC15-c and IC15-d. That flip-flop insures that the LOAD pin remains low until a clock pulse to load the counter has arrived.

The EFH signal is applied to the CLEAR pin of IC32 to insure that the clock always starts with the same polarity.

The fast-scan *line* counters are IC23 and IC39. Let's first look at how they work during the non-camera mode. Dot-counter signal "J" is used as the clock pulse, making the line counter advance one step for each line. Nine count-stages are needed; the extra stage is supplied by IC32 and is the least significant bit.

Figure 6 shows that the counter advances to a count of 262, is cleared, and starts again at zero. The clear pulse is supplied by IC47, which is hard-wired with the eight most-significant bits of the line counter. The CLEAR pin is held inactive when the camera is in use by connecting it to the logic-1 present at pin 10 of IC48.

The internal fast-scan vertical sync (IFV) comes from IC31.

When the camera display is viewed, the CLEAR function is disabled and the line counter is preset whenever a vertical-sync pulse occurs. When the counter is preset and the sync pulse from the camera is completed, the counter starts counting. When the count reaches 511, the next count, zero, allows display and writing to memory to begin. The time that is spent in counting from the preset value to zero is used to allow the camera's blanking-function to be completed.

The line counter advances two counts for each slow-scan line to allow each line to be displayed twice for an easier-to-view picture. There are 128 slow-scan lines, which means that 256 lines-per-field (or 512 lines-per-frame) will be displayed. Since NTSC standards call for 525 lines per frame, a small portion of the picture at the top and bottom is blanked.

Slow-scan clocks

There are two slow-scan clocks. One is derived from the master crystal oscillator and is used for all functions except slow-scan reception. The second clock is free-running, and is synchronized to the slow-scan horizontal-sync pulses. The clocks are selected by IC13, a 4PDT multiplexer.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise noted
R1-R3, R43, R78, R139, R202—22,000 ohms
R4, R201—10 megohms
R5, R6, R8, R9, R50, R80—15,000 ohms
R7—620 ohms
R10, R12, R15, R54, R93-R95, R102, R110, R209, R211, R714-R716—4700 ohms
R11, R13, R14, R16-R18, R86, R99—10,000 ohms, 1%
R19, R20, R27, R147—39,000 ohms
R21—20,000 ohms
R22, R23—18,000 ohms
R24—8200 ohms
R25, R26, R145, R146—82,000 ohms
R28, R42, R51, R136, R140, R142, R204, R205, R710, R711—10,000 ohms
R29—470,000 ohms
R30, R47-R49, R53—2200 ohms
R31, R79, R148—100,000 ohms
R32, R108—2700 ohms
R33—150,000 ohms
R34, R40, R52, R96, R109, R137, R144, R704, R717—1000 ohms
R35-R39—not used
R41—680,000 ohms
R44—47,000 ohms
R46—33,000 ohms
R55, R76, R112, R707—100 ohms
R56—100 ohms, trimmer potentiometer
R57—3300 ohms
R58, R77, R111—330 ohms
R59, R703, R712, R713—470 ohms
R60—100 ohms, 1%
R61-R75—26.1 ohms, 1%
R81-R84—not used
R85, R98—20,000 ohms, 1%
R87, R100—4990 ohms, 1%
R88, R101—2490 ohms, 1%
R89-R91—not used
R92, R200—680 ohms
R97—47 ohms
R103—820 ohms
R104—2000 ohms, trimmer potentiometer
R105—1200 ohms
R106, R107, R138, R141, R143, R203—1000 ohms, trimmer potentiometer
F113-R116, R125-R135—33 ohms
R117-R123—not used
R144—68,000 ohms
R149-R199—not used
R206, R207—220 ohms
R210—560 ohms
R212, R213—33.2 ohms, 1%
R314, R315, R317, R318—0.33 ohms, 2 watts
R316—220 ohms, 2 watts
R601—130 ohms, 2 watts
R701—1000 ohms, panel-mount potentiometer
R702—10,000 ohms, panel-mount potentiometer
R706—1 megohm
R708, R709—1800 ohms, 1 watt

All capacitors Mylar or mica unless otherwise specified
C1-C6—.022µF
C7, C24, C25, C38, C200, C240-C243—.01 µF ceramic disc
C8, C10, C12, C17—.0047 µF
C9—.0068 µF
C11, C207—.018 µF
C13, C15, C18, C19, C23, C263-C266—22 µF, tantalum
C14—10 µF, tantalum
C16, C22, C206, C703—.001 µF, monolithic or ceramic disc
C20, C201—27 pF, monolithic or ceramic disc
C21, C28-C31—470 pF
C26—not used
C27—33 pF, monolithic or ceramic disc
C32, C220-C227—0.1 µF, ceramic disc
C33, C41, C208, C317-C320—2.2 µF, tantalum
C34, C230-C237, C250-C262, C702—0.1 µF, ceramic disc
C35, C202-C205—100 pF
C37, C39—not used
C40—.047 µF
C309—500 µF, 12 volts, electrolytic
C310—9200 µF, 15 volts, electrolytic
C311—450 µF, 25 volts, electrolytic
C312—5800 µF, 25 volts, electrolytic
C601—500 µF, 25 volts, electrolytic
C701—2 µF, tantalum

Semiconductors
IC1-IC4, IC17-IC20, IC33-IC36, IC49-IC52—µPD411 (MM5280) 4K × 1 dynamic RAM
IC5, IC13, IC21, IC37, IC46, IC48, IC55—74LS157 quad 2-1 multiplexer
IC6, IC8, IC9, IC23, IC24, IC39-IC41—74LS163 presettable binary counter W/clear
IC7, IC26, IC57, IC58, IC61—75LS04 hex inverter
IC10, IC31, IC47—74LS30 8-input NAND gate
IC11, IC32—74LS107 dual JK negative-edge-trigger flip-flop
IC12—4046 CMOS phase-locked loop
IC14, IC15, IC45—74LS00 quad 2-input NAND gate
IC16, IC29, IC65—74LS74 dual D flip-flop
IC22, IC38, IC71, IC72—74LS153 dual 4-input multiplexer
IC25, IC42, IC88—74LS20 dual 4-input NAND gate
IC27, IC67, IC68—74LS10 triple 3-unit NAND gate
IC28, IC43, IC66—74LS25 dual 4-input NOR gate
IC30—74LS221 dual one-shot
IC44, IC62—74LS32 quad 2-input positive OR gate
IC54, IC56—74LS175 quad D flip-flop
IC59—74LS08 quad 2-input AND gate
IC60, IC63, IC64—74LS13 dual Schmitt trigger
IC66—3245 quad TTL-to-NMOS memory driver
IC69, IC70—74LS02 quad 2-input NOR gate
IC73-IC80—LM711 dual difference-comparator
IC81-IC84—not used
IC85, IC86—74LS86 quad EXCLUSIVE-OR gate
IC87—4066 CMOS quad bilateral switch
IC89—566 function generator
IC90-IC94, IC105—1458 dual 741 op-amp
IC95-IC104—not used
Q1, Q2, Q4, Q5, Q8-Q13—2N4124 or equivalent
Q3, Q6—not used
Q7—2N4126 or equivalent
LED1-LED3—jumbo red LED
D1-D11, D13-D18, D27-D33—1N914 or 1N4148
D12—not used
D19-D26, D601, D602—1N4007
DT601—gas discharge tube (Joslyn Electronics type 2022-44 or equivalent)
CB1—0.6-amp circuit breaker
T1—dual-secondary type: 1st secondary: 25VCT, 1 amp; 2nd secondary: 12.6VCT, 1.5 amps (see text and below)
T601—phone-line matching transformer (Microtran type 6112 or equivalent)
S1—4P5T rotary switch
S2-S4—N.O. momentary pushbutton switch
S5—SPDT toggle switch
S6—SPST toggle switch
J1-J2—not used
J3—36/72-pin PC-board edge connector (36 contacts for *each side* of board, two contacts per pin)
J4—socket for modular telephone connector, panel-mount
J5—DB25-S 25-pin female "date-type" socket, panel-mount
J6, J7—RCA-type phone jack, panel-mount
J8, J9—female coaxial connector, panel-mount (BNC- or SO230-type)
TB601—miniature 8-terminal barrier strip, PC-mount
RY601, RY602—4P2T 12-volts, PC-mount (Potter & Brumfield T10-E2-Z4-12VDC or equivalent)

Miscellaneous: PC boards, perforated construction board, IC sockets, RG59 cable, shielded audio cable, 4-conductor telephone cable w/modular plug, 3-conductor line cord w/plug, enclosure, hardware, etc.

The following are available from Robot Research Inc., 7591 Convoy Court, San Diego, CA 92111, (714) 279-9430: Assembled & tested Model 535 Picture Phone, FCC registered for direct connection to telephone line (KIT-1) (14 lbs.), $1195.00; assembled and tested No. 400929C main PC board (KIT-2) (4 lbs.), $495.00; assembled and tested Picture Phone chassis, including telephone adaptor board, but *less main board,* (KIT-3) (12 lbs.), $695.00; kit of No. 400929C main PC board with all main-board parts (KIT-4) (5 lbs.), $295.00; kit including chassis and chassis parts, and telephone adaptor board and parts, but *less main board,* (KIT-5) (12 lbs.), $445.00; telephone adaptor board kit including board and parts (KIT-6) (3 lbs.), $79.50; etched, drilled, and plated-through main board (KIT-7) (3 lbs.), $59.00; etched, drilled, and plated-through telephone adaptor board (KIT-8) (2 lbs.), $19.95; T1 (KIT-9) (4 lbs.), $29.50; T601 (KIT-10) (2 lbs.), $24.50; DT1 (KIT-11) (1 lb.), $8.50; kit of 32 1% resistors for main board (KIT-12) (1 lb.), $12.00; individual 1% resistor (KIT-13) (1 lb.), $0.35; Model 535 Picture Phone enclosure kit with mounting rails for main board and back plate for controls (KIT-14) (6 lbs.), $99.50; kit of *front panel parts only,* (KIT-15) (2 lbs.), $59.50; assembled & tested RF modulator, less power supply and enclosure (KIT-16) (1 lb.), $29.00; RF-modulator kit, less power supply and enclosure (KIT-17) (1 lb.), $19.50. For information on other parts, write to Robot Research.

CA residents please add 6% sales tax. All prices F.O.B. San Diego—check with UPS for shipping charges; please add $0.50 per $100.00 of value above first $100.00 for insurance. MC and Visa accepted.

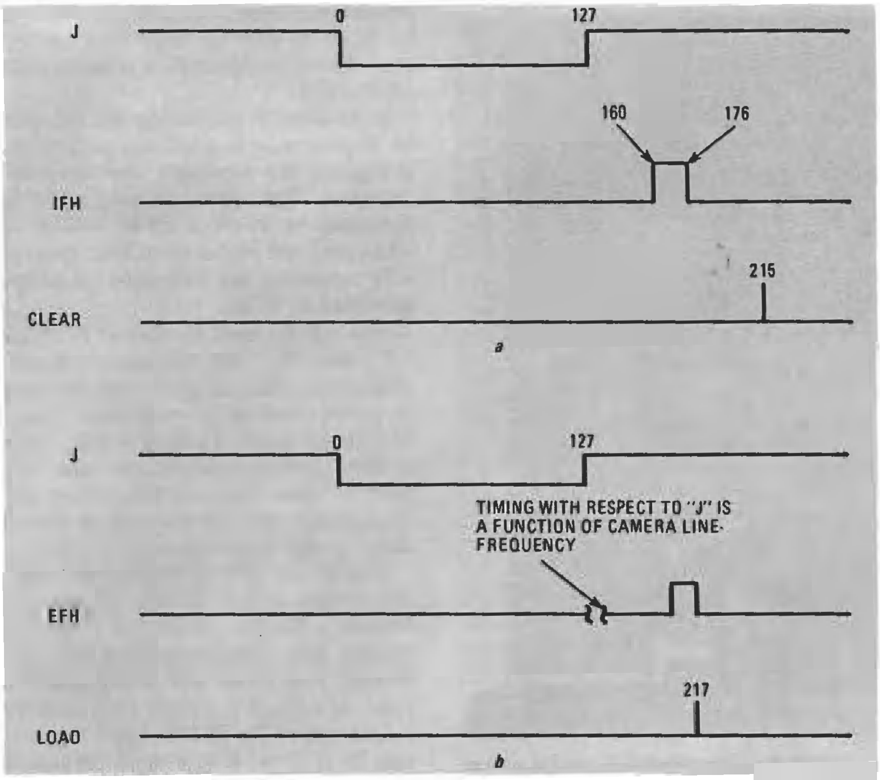


FIG. 5—FAST-SCAN dot counter has two modes—*a* is used for memory display, *b* for frame grabbing and camera display.

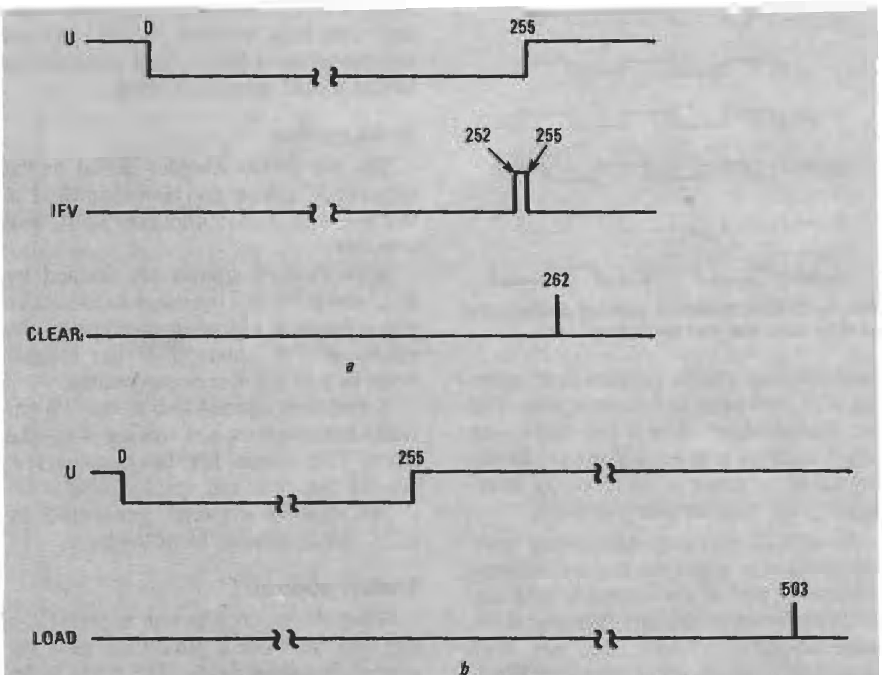


FIG. 6—FAST-SCAN line counter timing for memory display (*a*), and camera display (*b*).

The crystal-derived clock pulses begin with the 60-Hz "U" output of the fast-scan counter. It is divided by four by IC11. The resulting 15-Hz pulse train is applied to one input of PLL (*P*hase-*L*ocked *L*oop) IC12. The other input to that IC is the clock oscillator's output divided by 139, making the output of the PLL 15 × 139, or 2085 Hz. That becomes the slow-scan clock. It allows for 128 pixels and 11 sync counts per slow-scan line.

The synchronized clock pulses are generated by IC60. Its free-running frequency is controlled by R143. As the frequency is increased, the counter takes less time to address 128 memory "cells" and a shorter line is displayed. The clock is synchronized with the incoming signal by having the incoming slow-scan sync pulses cause the oscillator to stop and restart in phase with them.

The slow-scan clock is aligned with the fast-scan system by retiming the leading and training edges of the clock pulses with a section of IC16. A control signal, "Z," controls all the slow-scan functions. It is in operation only for the duration of the slow-scan memory-write cycle. Its use for retiming the slow-scan insures that the clock will not change during a slow-scan read or write memory access.

CAUTION:
FCC regulations prohibit the connection of this device to telephone lines without the use of an approved coupling device. The *only* exception to this is the assembled and tested unit available from the suppliers indicated in the Parts List. A coupler that meets FCC requirements will be described in the next part of this article. *Do not attempt to connect the Picture Phone you build without it—it's illegal to do so.*

Slow-scan counters

The slow-scan counter is made up of IC9, IC24, IC40 and IC41. They function the same way as their counterparts in the fast-scan circuit.

The slow-scan dot counter uses IC9 and IC24. It has two modes of operation—one to write slow scan to memory, and one to read it. Let's look at the read-mode first. The clock signal is derived from the crystal oscillator. The CLEAR signal is derived from IC25; the LOAD function is inactive. The counter is cleared at a count of 139 to provide 128 memory "cells" per line and 11 sync counts.

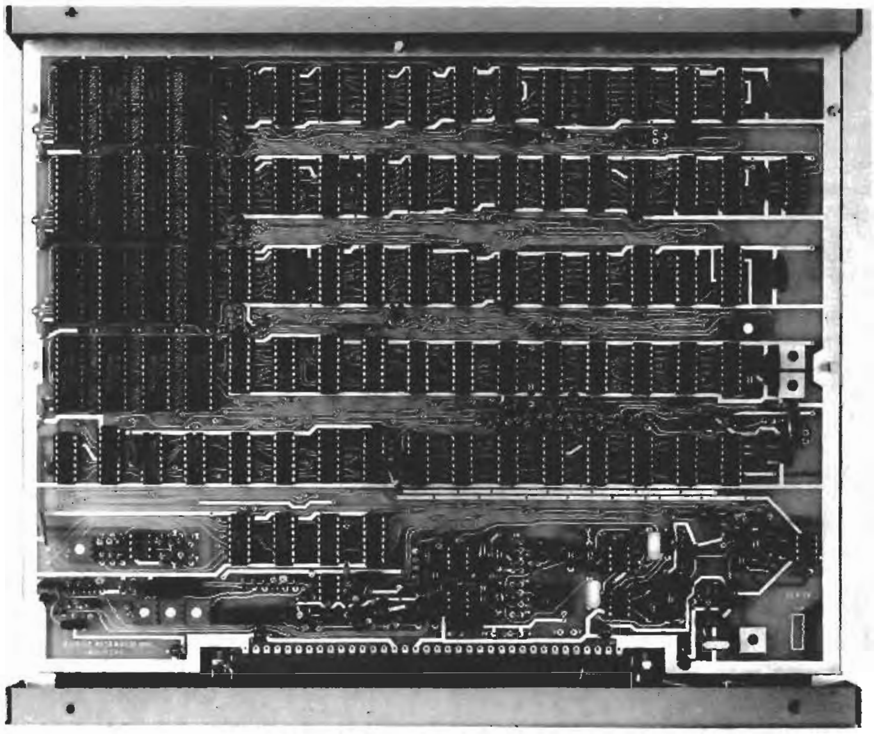
When slow scan information is to be written to memory, the free-running clock is used. The CLEAR signal is derived from a flip-flop formed from IC14-a and IC14-b. The flip-flop is set by an incoming sync pulse, and reset by a clock pulse. That is done to make sure that a clock pulse to clear the counter occurs while the CLEAR pin is low. The slow-scan sync pulse is allowed to reset the counter only after 128 counts (the end of a line) to insure noise immunity. In other words, false pulses can't interrupt a line as it is being written.

The line counter uses IC40 and IC41. A clock pulse occurs when each slow-scan line has been completed. The counter is reset to zero in the "read" mode at a count of 127 by the "U" signal. In the "write" mode it is cleared by the external vertical-sync signal applied to an RS flip-flop made from IC14-c and IC14-d. The flip-flop is reset by IC43 and IC45-a.

When a picture is grabbed from the camera, the line counter is set to all ones, and on the next clock pulse to all zeroes. That one-line time generates a slow-scan vertical-sync pulse.

Address selector

The memory address-lines are driven by the fast-scan counter to generate a video signal for fast-scan display, and also by the slow-scan counter to generate a slow-scan signal. The memory address-



COMPLETED MAIN BOARD of the Picture Phone plugs into 36/72-pin edge connector mounted at front of enclosure.

lines are connected to the appropriate counter by an address multiplexer made up of IC5, IC21 and IC37—4PDT switches, each of which switches four address lines. Resistors on the leads to the memory IC's damp reflections so that the address voltages will not ring.

The address lines are in the "slow scan" mode during time "Z," which takes place for 16 dots following the right-hand edge of the fast-scan picture. In other words, slow-scan memory access takes place just after fast-scan access for the current line is completed. When "Z" becomes active, the address multiplexer switches to slow scan, and the slow-scan counter is inhibited from changing state. The "Z" signal is generated by IC25-b.

Fast-scan memory multiplex

To obtain the speed required for fast-scan operation, memory operation is multiplexed. The multiplexing is done with the memory CE (*C*hip *E*nable) pulse. Figure 7 shows the CE pattern. Note that successive memory columns are overlapped by 50%.

The CE signal is formed by a delay flip-flop, IC65, that uses "B" as data and "A" (delayed) as a clock signal. Signal "A" is delayed by an RC circuit that feeds Schmitt trigger IC60. The delay is provided to insure that memory address-lines are stable before CE goes high.

The CE signal is a zero–to–+12-volt pulse translated from 5-volts by IC66.

Slow-scan memory multiplex

Memory multiplexing is performed by the two lowest-order bits on the memory address-lines. In other words, each bit of

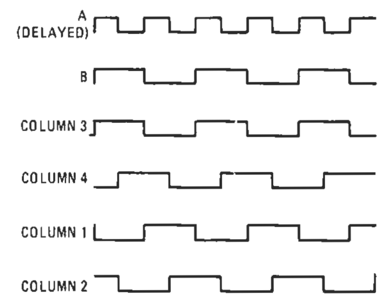
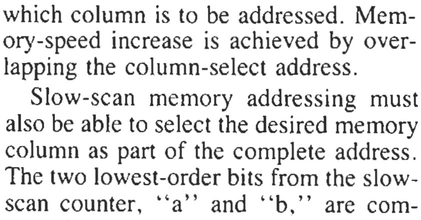


FIG. 7—EACH COLUMN of memory overlaps the next by 50%. See text for details.

the 4-bit pixel nybble requires four memory IC's, arranged in four columns. The two lowest-order address bits determine which column is to be addressed. Memory-speed increase is achieved by overlapping the column-select address.

Slow-scan memory addressing must also be able to select the desired memory column as part of the complete address. The two lowest-order bits from the slow-scan counter, "a" and "b," are combined into column-select pulses by IC69.

Each of the 16 memory IC's has a CS (*C*hip *S*elect) pin that is used for slow-scan memory column selections. The CS



REAR PANEL of Picture Phone. Circuit-breaker reset is located above line cord at left.

pulses come from IC69 and are passed on by IC70 during the slow-scan access time. That IC holds all IC's selected at all other times.

In addition to addressing the memory for slow scan, it is necessary to time the storage of the incoming slow-scan information. The required timing signal is generated by IC71, a DP4T switch of which only one pole is used. The inputs of IC71 consist of the slow-scan CS pulses generated by IC69.

The signals used to control IC71 are "X" and "Y," the fast-scan CS pulses. Therefore, when the slow- and fast-scan CS pulses coincide, a "read store" pulse will be generated. In other words, when IC69 has selected column one, and "X" and "Y" have also selected column one, then—and only then—will a "read store" pulse be generated.

Multiplexer IC71 is enabled by a control signal called SSME (*S*low-*S*can *M*emory *E*nable), which is active for exactly four consecutive fast-scan addresses. That means that SSME is active just long enough to sample each memory column once. The SSME signal is generated by IC27-b. It is a small portion of "Z," which is the time for slow-scan address to be applied to the memory. Since SSME takes place later than "Z," any transients created by the address switchover from fast- to slow-scan die out before a read sample is taken.

Write control

The WE (*W*rite *E*nable) signal to the memory IC's must also be multiplexed so that the write and CE inputs to an IC will coincide.

Write-control signals are formed by IC67 and IC68-b. Those signals are active one column at a time in response to the values of "A" and "B," the lowest-order bits of the fast-scan counter.

A common control-line to the WE encoder determines when writing is to take place. That control line has two sourses, one for fast scan and one for slow scan.

The control signals, generated by IC28, are combined by IC44-b.

Snatch control

When the SNATCH button is pressed, a one-shot puts out a pulse that lasts for several fast-scan fields. The pulse is retimed by a section of delay flip-flop IC29 so that the useful SNATCH command starts and ends at the bottom of a TV picture. That prevents any errors that might result from the SNATCH pulse ending in the middle of a picture. Another section of IC29 retimes display selection so that the changeover between display memory and the camera takes place when the picture is blanked.

In the next part of this article we'll discuss the telephone interface and power-supply circuits. We will also begin to look at the construction and alignment of the device. **R-E**

Part 3

THE FIRST TWO PARTS of this article discussed the theory of operation of the main board of the Picture Phone. We'll now describe the telephone adaptor board and power supply. We'll also begin to look at the construction of the device. As always, it will be helpful to have the previous parts of this article as we proceed.

Picture Phone

The telephone adaptor board, the power supply, and construction of the device are the topics covered in this month's look at the Picture Phone.

JOSEF BERNARD,
TECHNICAL EDITOR

Telephone adaptor board

The telephone adaptor board, shown in Fig. 8, serves two purposes: it serves as an interface between the main board and the telephone line, and also allows the user to switch between VOICE and PICTURE modes.

Transformer T601 provides impedance matching between the main board and the telephone line's 600-ohm requirements. It also provides electrical isolation between the phone line and the Picture Phone. The transformer contains a grounded electrostatic shield (indicated by the dashed line) to reduce hum. Additional protection to the phone line is provided by a static-discharge device, DT1.

It must be noted that, while those precautions should provide sufficient protection to satisfy your telephone company's requirements for connecting non-company equipment to its lines, the Picture Phone *must* be used with a coupling device approved by the phone company.

The Picture Phone is connected to the phone line by a standard four-conducter phone cable terminated in a modular phone plug. A modular jack on the rear of the Picture Phone cabinet accepts the plug from an ordinary telephone. The telephone can be used normally when the Picture Phone is off or when it is in the VOICE mode. Connections between the modular jack and the adaptor board are made through an 8-terminal barrier strip, TB601.

The second function of the telephone adaptor board is to provide switching between VOICE and PICTURE modes. Two relays, RY601 and RY602 provide that function. They are controlled by pushbuttons S2 and S3 on the front panel. When turned on, the Picture Phone "comes up" in the VOICE mode and the telephone can be used normally. When the PICTURE switch is depressed, though, several things happen.

First, the telephone is disconnected from the line. Usually, that would cause the phone company's equipment to "think" that you had hung up, and disconnect you. The Picture Phone, however, through relay R601, provides a "holding voltage" which, as far as the phone-company equipment is concerned, means that the phone is still off the hook, and the connection is maintained.

With the telephone out of the circuit, audio is routed to and from the main board of the Picture Phone in the form of a slow-scan video signal, composed of tones ranging from 1500 Hz to 2300 Hz (see Part 1). The mode switch, S1, in the center of the front panel determines whether the slow-scan audio will be transmitted or received.

When the PICTURE switch is pushed, the relays latch, and the Picture Phone remains in the PICTURE mode until the VOICE button is pushed.

Associated with those two switches are LED2 and LED3, which indicate the current status of the device.

Power supply

The Picture Phone requires five working voltages: plus-and-minus five volts DC, plus-and-minus 12 volts DC, and −20 volts DC. The power-supply schematic is shown in Fig. 9. While a single transformer with two secondaries can be used to obtain all those voltages, it may be difficult to locate; such a transformer is available from the supplier indicated in the Parts List (see last month's issue).

You may, however, choose to use two transformers. Both should be center-tapped. The first should be capable of supplying about 12.6 volts *on each side* of the center tap, for a total of about 25 volts at one amp. The second transformer should be capable of supplying about 6.3 volts on either side of the center tap, for a total of 12.6 volts at 1.5 amps.

Standard bridge-rectifier/capacitor circuits are used, along with tab-type regulators to obtain the final working voltages. The −20 volts is taken from the *input* to the −12-volt regulator. A 0.6-amp circuit breaker, CB1, is used for protection.

The output of the +5-volt supply is used to drive LED1, the POWER indicator mounted on the front panel.

Front-panel controls

The functions of some of the front-panel controls have already been explained; this is what the others do:

Snatch button (unlabelled), S4, is used when you wish to "grab" a frame of video to be transmitted. It is active only when S5, the MANUAL/AUTOMATIC switch is in the MANUAL position. When S5 is in the AUTOMATIC position, a new frame will be snatched automatically every eight seconds.

The BRIGHTNESS and CONTRAST controls, R307 and R305, control the quality of the image that you are transmitting. (There will be more about them in the section on using the Picture Phone.) It is assumed that the party with whom you are exchanging video is sending a good quality picture, so no external controls are

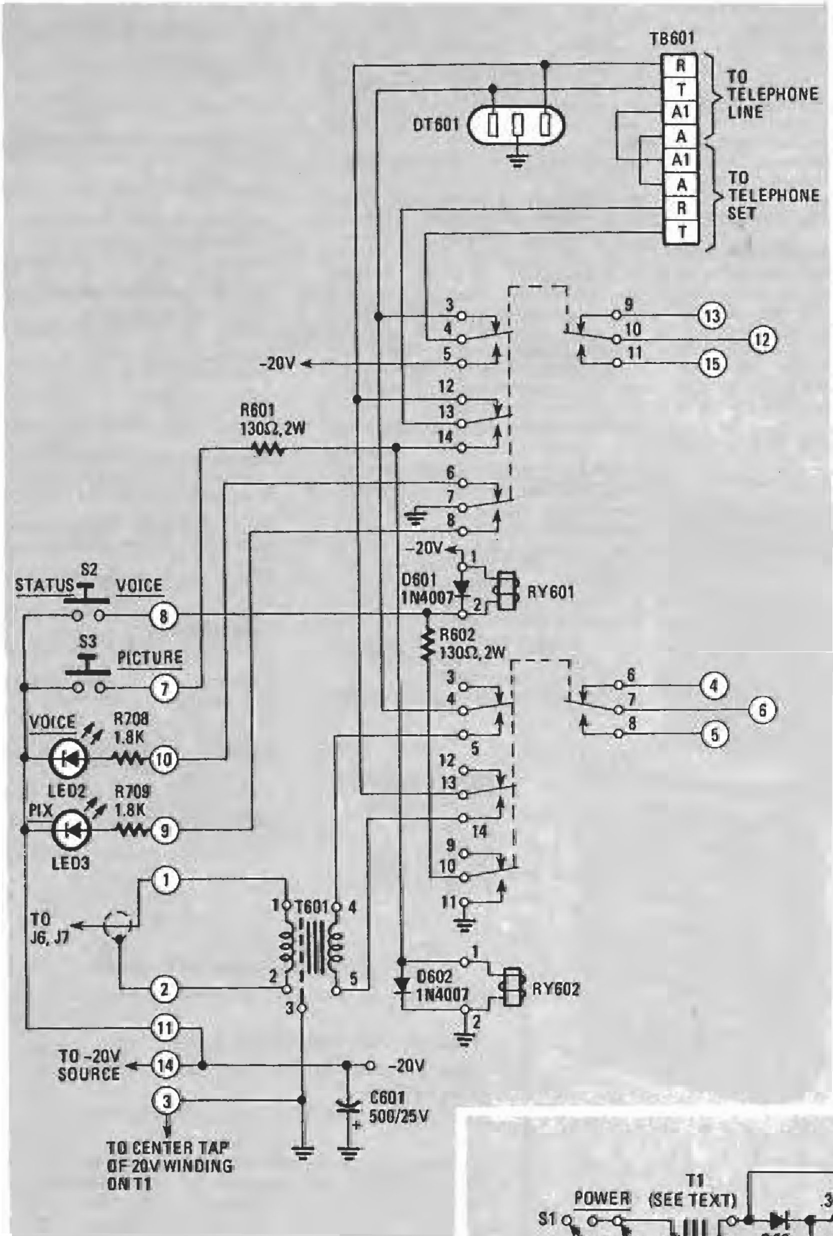


FIG. 8—TELEPHONE ADAPTOR BOARD provides switching and impedance-matching functions, and also controls status indicators.

provided for RECEIVE adjustments.

The final control that needs explaining is the five-position mode switch, S1. In its fully-counterclockwise position, GRAY SCALE, it loads a four-level gray scale into memory for calibration purposes. The next position, CAMERA, allows you to view a real-time digitzied image from your camera on your monitor. That permits both focusing and composition, as well as allowing you to set the BRIGHTNESS and CONTRAST controls for best results.

The TRANSMIT position is used when you are in the PICTURE mode to transmit the video stored in the Picture Phone's memory. The next position, HOLD freezes a frame of received or transmitted video in memory and displays it indefinitely, regardless of whether new video is available or not. It is particularly useful if you want to be able to look at a received image while discussing it in the VOICE mode.

Finally, the function of the RECEIVE position should be obvious—it loads video into the Picture Phone's memory for display on your monitor.

There is one connector on the rear of the cabinet that should be explained. That is a 25-pin DB25-S socket of the type used on computer equipment. It can be used for the connection of remote switches for SNATCH, VOICE/PICTURE, etc.

Construction

Construction of the Picture Phone can be divided into two parts—the three boards (main, phone adaptor, and power supply)—and chassis wiring. It's probably best to complete the first two boards first, and then combine the power-supply board and chassis wiring.

Because of the large size and complexity of the double-sided main board (almost 10 × 12 inches) it is impractical to reproduce foil patterns for it here with clarity. If you want to try to make your own board (it's available from the supplier indicated in the Parts List), full-sized printed (*not* film) positives can be obtained by sending $1.50—along with a note indicating that you want the foil patterns for the board *and* the address to which they are to be sent—to: Picture Phone, **Radio-Electronics,** 200 Park Avenue South, New York, NY 10003.

The parts-placement diagram for the main board is shown in Fig. 10; refer also to Fig. 11. Assembly of the board is straightforward, and should present little difficulty as long as you proceed with care. Don't rush the job, for that is sure to

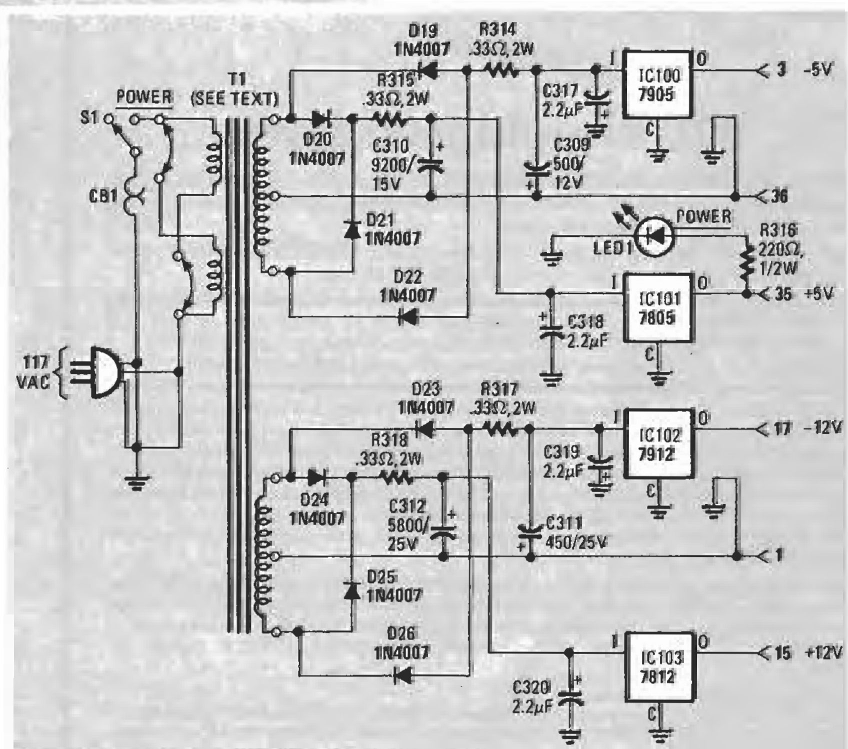


FIG. 9—POWER SUPPLY provides ±12 volts, ±5 volts, and -20 volts. See text and Parts List (in last month's issue) for T1 information.

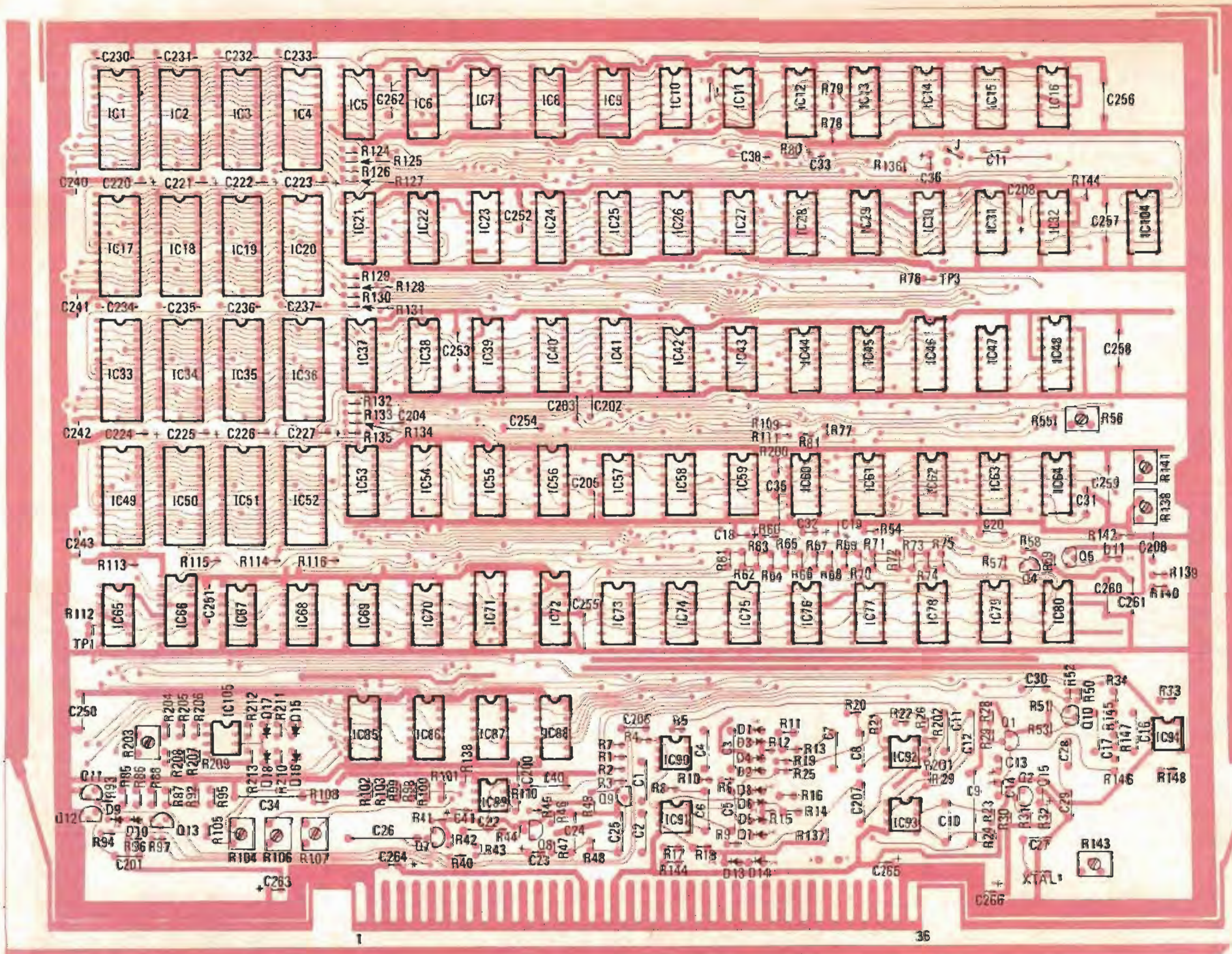


FIG. 10—ALL IC's face in the same direction. Note that resistors and diodes are mounted vertically to conserve board space.

lead to problems, and it will be a long time before you solve them and have your Picture Phone operating.

It's best to insert all the IC sockets first (note that they all face in the same direction) and make sure that you *don't* insert 14-pin sockets where there should be 16-pin ones. Be sure that *all* the pins are soldered—with that many connections, it's easy to miss one, and you'll spend hours or days before you discover that one unsoldered socket-pin is the reason that the equipment isn't functioning.

Next install the resistors and diodes. Note that they are all mounted vertically (standing on end). Be extremely careful about the polarity of the diodes, and don't forget the two short jumpers. Finally, install the capacitors, again being careful to observe the polarities of the tantalum types. **Do not insert any IC's into their sockets yet.** When you're finished with the main board, set it aside temporarily and go on to the phone adaptor board.

That double-sided board, whose foil patterns are shown in Figs. 12 and 13, and parts-placement diagram in Fig. 14, is easy compared to the main board. The parts should slip right into the holes—just make sure that the electrolytic capacitor,

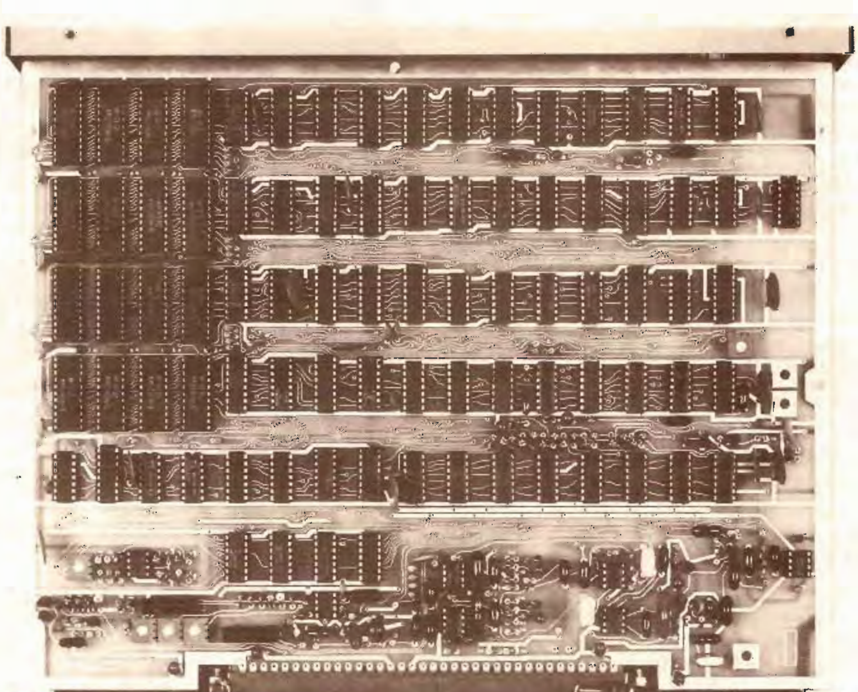


FIG. 11—THIS PHOTO shows how the main board should look when it is correctly assembled. It is shown here mounted in the enclosure.

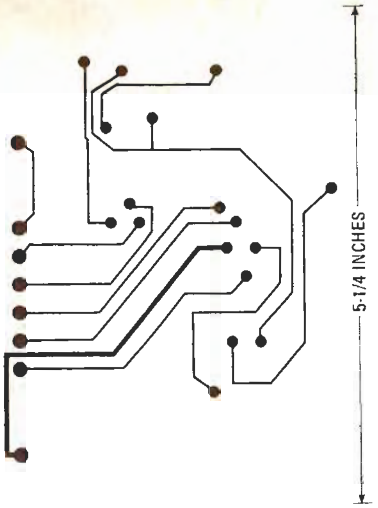


FIG. 12—FOIL PATTERN for top of telephone adaptor board.

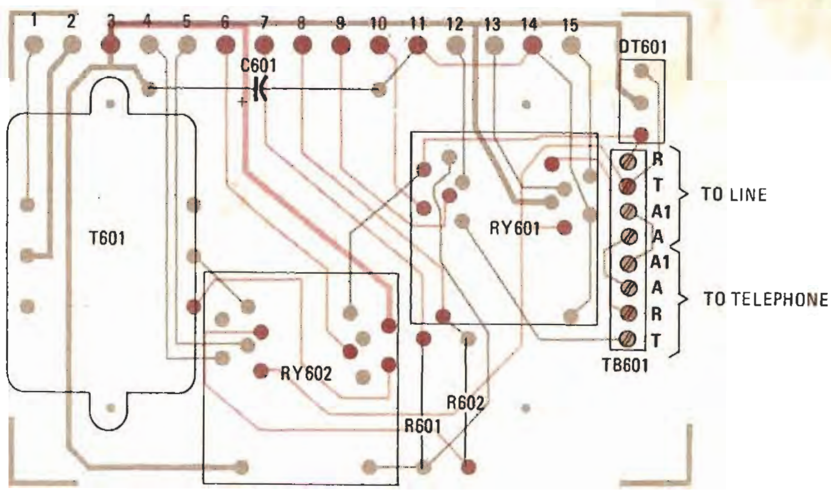


FIG. 14—USE SMALL PC-BOARD pin connectors at positions 1-15 to make it easier to connect wires to telephone adaptor board.

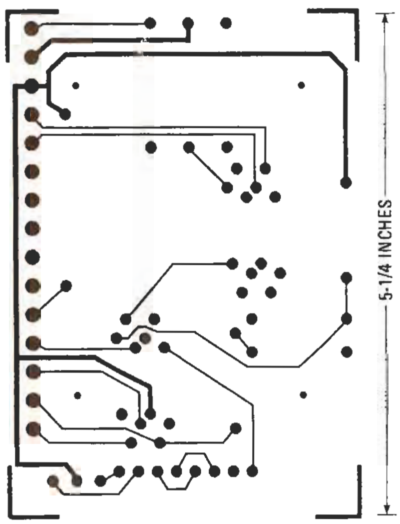


FIG. 13—FOIL PATTERN for bottom of telephone adaptor board.

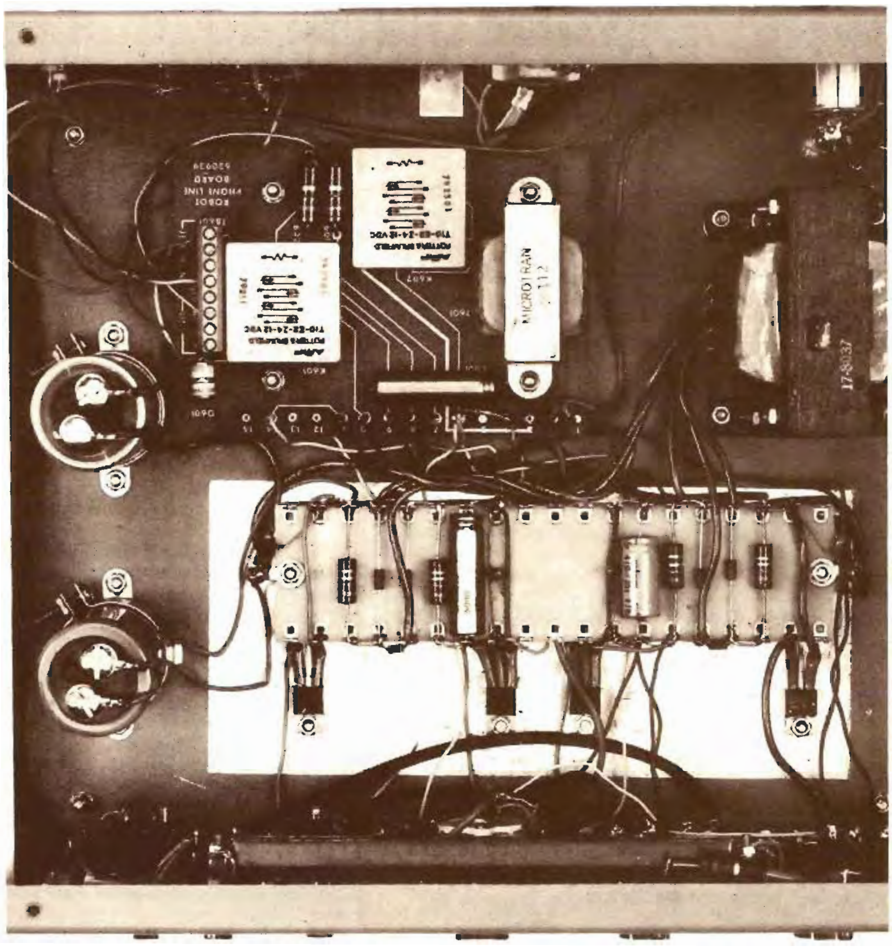


FIG. 15—POWER SUPPLY and associated components. Bottom of enclosure is used as heat sink for regulators.

C601, is oriented properly, and that the 8-terminal barrier strip is inserted so that the phone wires can be connected from the outside of the board. Using small PC-board pin-connectors at positions 1-15 will make it easier to make connections to the board later.

Most of the power supply, shown in Fig. 15, can be constructed on a piece of perforated construction board; the two large capacitors, C310 and C312, and the four regulators will be chassis-mounted and wired to the board. Be sure to allow for the many ground connections that will have to be made from that board.

The two off-board capacitors should be bracket-mounted to the chassis as shown in Fig. 15, and the regulators secured to the top side of the bottom of the case. Be sure that the tabs of the *positive* regulators make good electrical contact with the case, and be sure that the *negative* regulators are insulated from the case (use nylon hardware, mica insulators, and silicone grease).

When the three boards are complete, you can install the chassis-mounted components, such as the power transformer, switches, jacks, LED's, the two large capacitors, etc. It will probably be easier *not* to mount the 36/72-pin edge connector for the main board at this point, because doing so will make it awkward to make connections to it. You'll find that the liberal use of terminal strips will make routing of supply and control voltages more convenient.

Mount the power-supply board in the case first, using standoffs, and connect it to the two large capacitors and to the regulators. Use "spaghetti" on the leads of the regulators, as shown in Fig 15, for safety.

When we continue our look at the Picture Phone, we will finish up the construction of the device. We'll also look at how it is aligned as well as how it is used. Also covered will be how to connect it to the phone lines. **R-E**

PICTURE PHONE

Your Picture Phone should now be nearly complete. Here's how to finish it, calibrate it, set it up, and use it.

JOSEF BERNARD
TECHNICAL EDITOR

Part 4 BEFORE YOU CAN PUT your Picture Phone into service, you'll need to buy and install a telephone coupler. This month we'll look at those, and show you how to align and use your Picture Phone. But first, let's finish up the construction.

When running lines for the AC voltages, twist wires carrying similar voltages together; that will help reduce 60-Hz hum in the system. Also try to keep the wires as close to the chassis as possible, again to reduce hum.

Next, install the telephone adaptor board, again using standoffs. You can now proceed with the chassis wiring, shown in Fig. 16. It's a good idea to color-code your wires—red for +5 volts, blue for +12 volts, orange for control signals, etc. That will make wire-routing easier and also help you in troubleshooting, should that be required.

Aside from keeping things neat, perhaps the most difficult part of the chassis wiring is the MODE switch, S1. Make sure that all the diodes on the switch are oriented correctly, and be liberal with the "spaghetti" to prevent shorts. Thinning the braid of the shielded cables before twisting and tinning it may make it easier for it to fit through the switch lugs.

Note that the use of the DB25-S connector (see Fig. 17) is optional, but it's a good idea to install it in case you decide to use it later. Also, R710 (10K) is intended for use with tape recorders having a LINE or AUX input. If your recorder has only a MIC input, use a much higher value—at least several hundred kilohms.

Your last step should be to mount the edge connector for the PC board, again using standoffs. It should be at a level where the board can plug into it without touching the components below it. You will also have to provide a frame and bracket to support the sides and rear of the board. Figure 15 (see last month's issue) shows you how that can be done (note the nylon standoffs into which the board snaps).

Before plugging the PC board into the edge connector, turn the unit on and check to make sure that the right voltages appear at the right pins. If everything checks out, turn the power off, allow a couple of seconds for the capacitors to discharge (you can tell by watching the front-panel LED's), and then carefully insert the board into its connector.

Again, turn the power on and, this time, check for the proper voltages at the IC-sockets. An ordinary straight pin makes an ideal probe for the purpose—it will slip right into the socket hole you're checking. If everything looks OK, turn the power off and insert the IC's into their sockets.

Certain pins on IC23, IC31, and IC47 have to be disabled for timing purposes. That is done as shown in Fig. 18, by bending the unused pins up until they stick out at right angles to the others and cannot fit into the sockets.

An inexpensive coupler

Telephone couplers, sometimes known as wiring protectors, are required to prevent the possibility of damage to telephone-company equipment by devices (such as the Picture Phone you built) that have not been approved by, and registered with, the FCC. Unfortunately, homebrew equipment—even if built from a kit—cannot, at least, not easily—obtain FCC approval, and an approved coupler must be used.

There are a number of couplers that

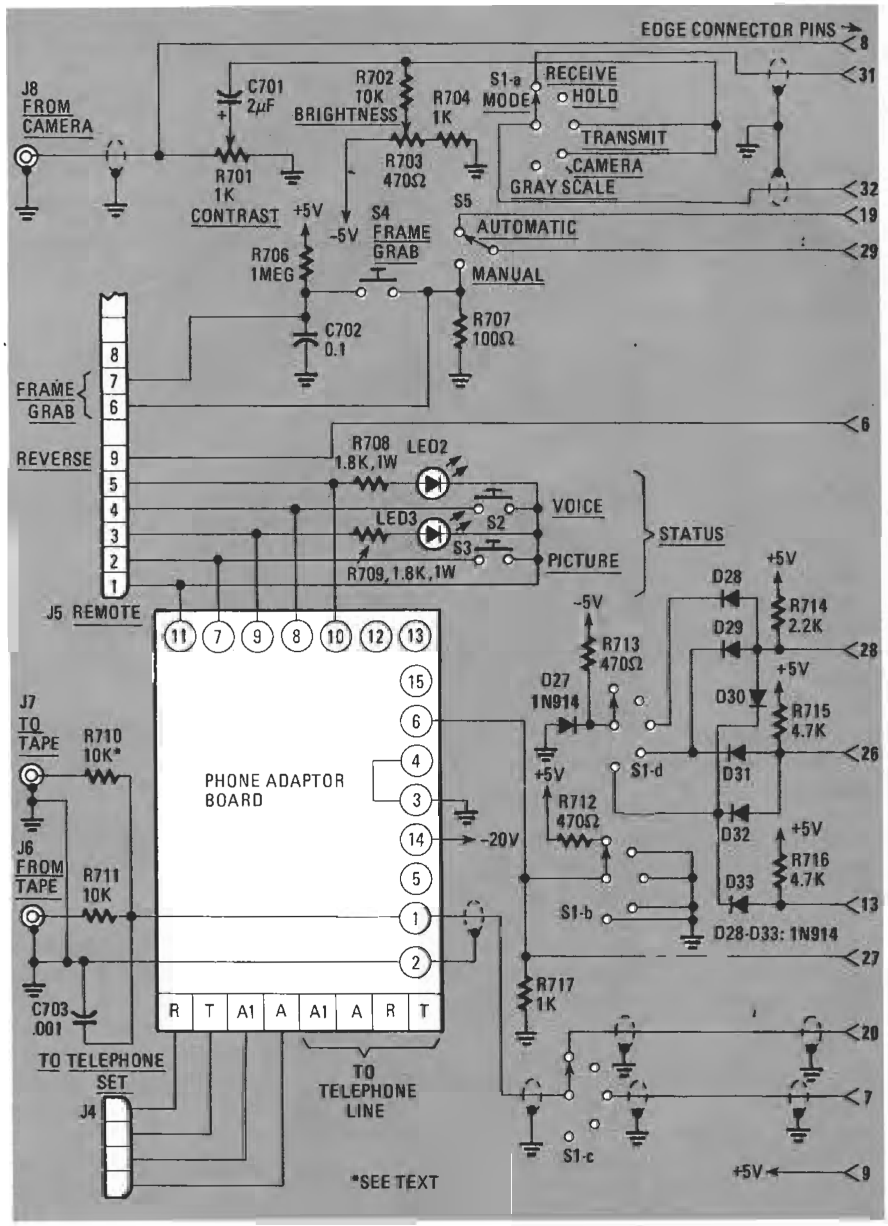


FIG. 16—WIRING DIAGRAM for chassis-mounted components and for connections to edge connector. Be especially careful in wiring diodes to S1-d.

FIG. 17—REAR PANEL of Picture Phone. Circuit-breaker reset is located above line cord at left.

will do the job for us available from various manufacturers; the one we'll use as an example is the Elgin Electronics model *EWP130A Voice Coupler*, which costs about $85 (see the Parts List for ordering information).

Figure 19 shows the terminals on the *EWP130A* board, and the connections that have to be made to the Picture Phone and the telephone company's modular telephone jack. Note that only the *tip* (green) and *ring* (red) leads are used.

The coupler is designed to pass audio signals and to translate the ring signal and on-hook/off-hook voltages into relay closures that will supply the appropriate voltages to the telephone equipment on your side of it. (You can do almost anything on *your* side of the coupler; that's why it's used—to protect the equipment on the telephone-company side from damage.)

The coupler requires two operating voltages and, if the telephone is going to be permanently connected to the Picture Phone, those voltages must *always* be available. Only a few hundred milliamps are required, and a suitable supply is shown in Fig. 20. It provides −24-volts DC to operate the coupler's relays, and 117-volts AC at 30 Hz (derived by placing diode D801 in the AC line) to ring the telephone's bell.

The coupler comes with a cord and modular plug, which is inserted in the wall jack that your phone would normally connect to (refer back to Fig. 19.) The telephone itself is connected to the modular jack on the rear of the Picture Phone and the user-side (your side) of the coupler to the "T" and "R" *output* terminals on the Picture Phone's telephone adapter board.

While the power supply for the coupler can be mounted inside the Picture Phone (and the 117-volts AC taken from its line cord *before* the power switch), the coupler should be mounted as close as possible to the wall jack it will be plugged into.

Be sure to notify your telephone company of the following:

1. The particular line to which you will be making your connection.
2. The type of jack used (type RJ11W in the case of modular wall jacks).
3. The FCC registration number of the coupler.
4. The ringer-equivalence number of the coupler.

Checkout and adjustment

Now that you know how to connect the Picture Phone to the phone line in a perfectly legal fashion, it's time to make sure that it works properly and to calibrate it. (If you run into problems, skip to the section on troubleshooting.) Perform the

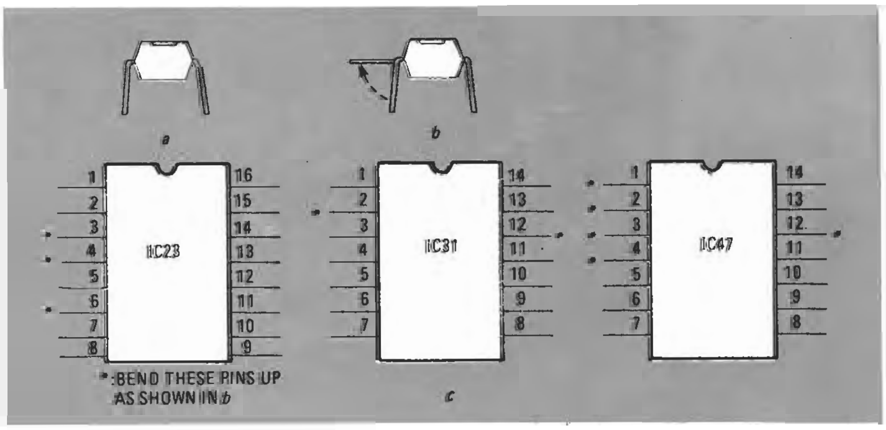


FIG. 18—SECTIONS OF IC23, IC31, and IC47 are disabled by bending IC pins up (*b*). Pins to be bent are indicated by asterisks in *c*.

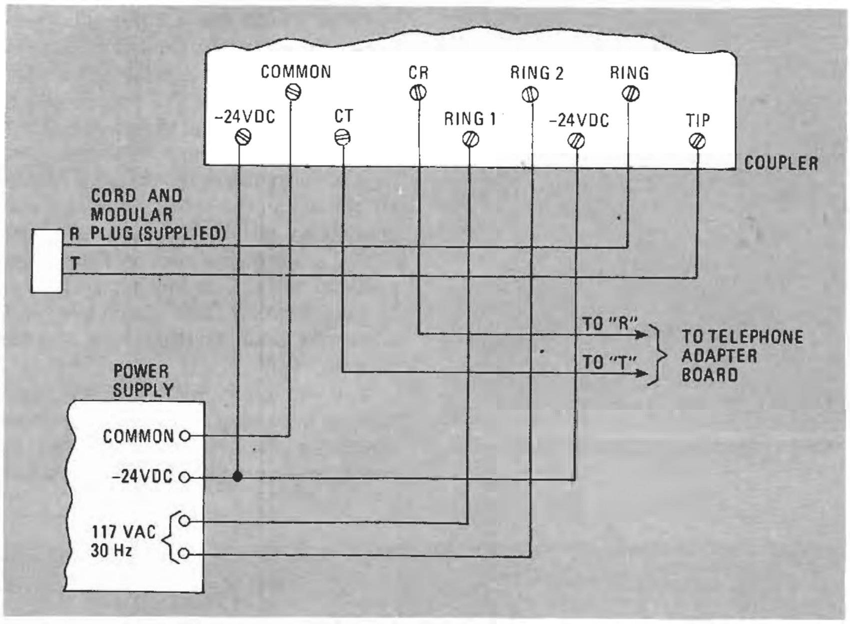


FIG. 19—CONNECTIONS TO AND FROM THE EWP130A coupler. Details of the power supply will be found in Fig. 21.

ORDERING INFORMATION

The following are available from Robot Research Inc., 7591 Convoy Court, San Diego, CA 92111, (714) 279-9430: Assembled & tested Model 535 Picture Phone, FCC registered for direct connection to telephone line (KIT-1) (14 lbs.), $1195.00; assembled and tested No. 400929C main PC board (KIT-2) (4 lbs.), $495.00; assembled and tested Picture Phone chassis, including telephone adaptor board, but *less main board,* (KIT-3) (12 lbs.), $695.00; kit of No. 400929C main PC board with all main-board parts (KIT-4) (5 lbs.), $295.00; kit including chassis and chassis parts, and telephone adaptor board and parts, but *less main board,* (KIT-5) (12 lbs.), $445.00; telephone adaptor board kit including board and parts (KIT-6) (3 lbs.), $79.50; etched, drilled, and plated-through main board (KIT-7) (3 lbs.), $59.00; etched, drilled, and plated-through telephone adaptor board (KIT-8) (2 lbs.), $19.95; T1 (KIT-9) (4 lbs.), $29.50; T601 (KIT-10) (2 lbs.), $24.50; DT1 (KIT-11) (1 lb.), $8.50; kit of 32 1% resistors for main board (KIT-12) (1 lb.), $12.00; individual 1% resistor (KIT-13) (1 lb.), $0.35; Model 535 Picture Phone enclosure kit with mounting rails for main board and back plate for controls (KIT-14) (6 lbs.), $99.50; kit of *front panel parts only,* (KIT-15) (2 lbs.), $59.50; assembled & tested RF modulator, less power supply and enclosure (KIT-16) (1 lb.), $29.00; RF-modulator kit, less power supply and enclosure (KIT-17) (1 lb.), $19.50. For information on other parts, write to Robot Research.

CA residents please add 6% sales tax. All prices F.O.B. San Diego—check with UPS for shipping charges; please add $0.50 per $100.00 of value above first $100.00 for insurance. MC and Visa accepted.

For information on where to obtain the coupler described in the text write to: Elgin Electronics, 802 Walnut Street, Waterford, PA 16441. The price of the EWP130A coupler is $87.00, ppd.

calibration *without* connecting the device to the phone line—if you leave it connected while you are working on it, anyone who tries to call you will get a busy signal. Instead, temporarily use a small piece of wire to jumper the contacts on the PICTURE switch so you are constantly in the VIDEO mode.

To perform the alignment you'll need a frequency counter, cassette recorder, and a video monitor or a TV set with an RF modulator (which you're going to need anyway when you put the Picture Phone to use). A TV camera, which, of course, you'll eventually require, is not needed for most of the alignment procedure.

The first step is to set the proper frequencies for slow-scan sync, white level, and black level. Connect a frequency counter to the TO TAPE jack and then temporarily connect TP2 (see Fig. 2 in the August issue) to +5 volts. Adjust the SYNC trimmer, R107 until you get a reading of 1200 Hz, the slow-scan sync frequency.

Next, ground TP2 and turn the front-panel CONTRAST control fully counterclockwise and the BRIGHTNESS control fully clockwise (Fig. 21 shows the front-panel controls). With the FRAME GRAB switch in the MANUAL position push the FRAME GRAB *button* to load a frame of white into memory. Adjust the WHITE trimmer potentiometer, R104, until you get a reading of 2300 Hz on your counter.

Finally, with TP2 still grounded, turn the CONTRAST control fully *clockwise,* and the BRIGHTNESS control fully *counterclockwise*. Adjust the BLACK trimmer, R106, until your counter reads 1500 Hz, the frequency used in slow scan to represent black. That completes the frequency adjustments for slow-scan output and you can remove the lead from TP2.

The next step is to adjust the brightness and contrast levels for slow-scan reception. That will be done by referring to the four-level (black, two shades of gray, and white) gray scale generated by the Picture Phone.

First, set the MODE switch to the GRAY SCALE position and snatch a gray scale using the FRAME GRAB button. **Do not be alarmed if, with no TV camera connected, you see a crazy jumble of lines on the screen in the GRAY SCALE or CAMERA mode. That is normal, and is due to the fact that the Picture Phone is receiving no fast-scan sync signal. The gray scale can be viewed by putting the MODE switch into the TRANSMIT or HOLD position.** You may notice some slight glitches where one gray shade meets the next. That, too, is normal, and will not be obvious when you are viewing slow-scan pictures.

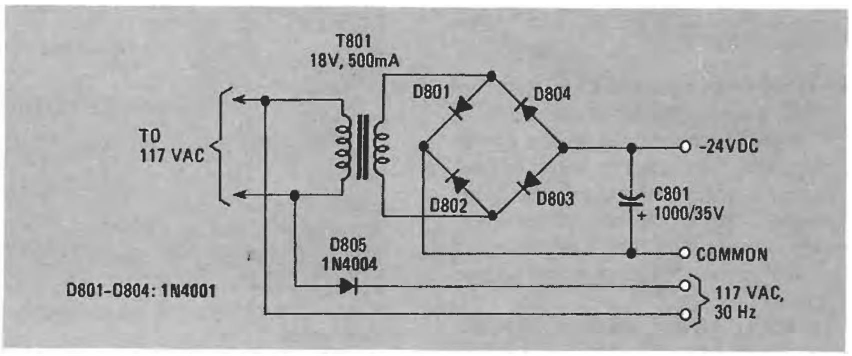


FIG. 20—POWER SUPPLY for use with the EWP130A telephone coupler. It can easily be built on perforated construction board and mounted inside the Picture Phone enclosure.

With a gray scale being displayed from memory (MODE switch in the HOLD position) adjust the CONTRAST control of the monitor or receiver until the white bar at the right just begins to "bloom"—blend with the next shade of gray. Then adjust the monitor or TV set's BRIGHTNESS control until the black bar on the left matches the blanked area of the screen. Do not reduce the brightness below the point where the raster lines just disappear from the screen. Your display device should now be correctly adjusted for slow-scan viewing.

Now you can adjust the Picture Phone

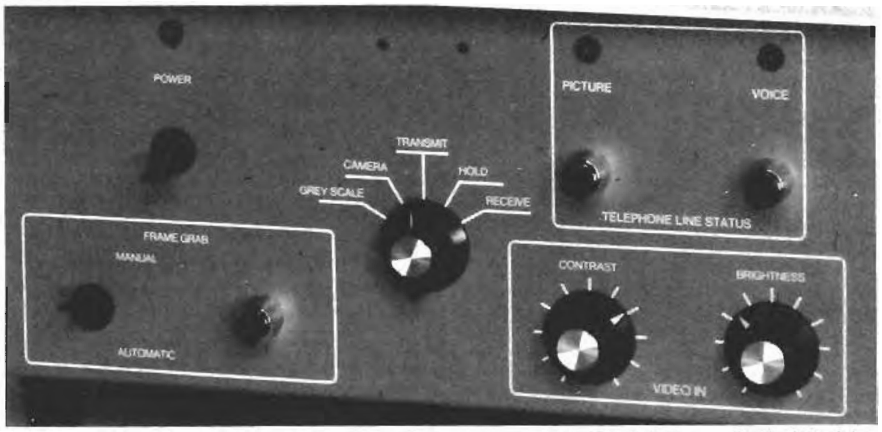


FIG. 21—PICTURE PHONE'S front-panel controls. The FRAME GRAB button is below and to the left of the five-position MODE switch.

PICTURE PHONE DIRECTORY

Should you build—or purchase—your own Picture Phone, **Radio-Electronics** would like to know about it. We hope to publish a directory of Picture Phone users so, if you're interested in talking to (and seeing) others, be sure to include your telephone number.

for slow-scan reception. Connect a shielded audio cable from the TO TAPE jack of the Picture Phone to the line or mike input of the cassette recorder and, with a gray scale being displayed in the TRANSMIT mode, record about five-minutes worth. You may have to adjust the SINE trimmer, R204, to get an acceptable recording level.

Connect a second shielded cable between the output or earphone jack of the recorder and the FROM TAPE jack on the Picture Phone. Rewind the tape you just made and set the Picture Phone's MODE SWITCH TO THE RECEIVE position. Play back the gray-scale tape and adjust trimmers R138 (BLACK) and R141 (WHITE) until the recorded gray scale matches a frame-grabbed one (viewed in the TRANSMIT position).

If you are not able to make the recorded center two gray shades match the ones viewed directly from the Picture Phone, R138 is probably not set correctly. Change its setting slightly, and then try to match the two gray scales using R141. In the end, you should be able to make four distinctly different brightness levels.

The last two adjustments require a TV camera. A digitized, *real-time* image can be viewed with the MODE control in the CAMERA position. Focus on a round object—a dinner plate or fisbee, perhaps—and grab a frame of it. Use the SNATCH WIDTH trimmer, R56, to adjust the width of the picture stored in memory (viewed in the TRANSMIT or HOLD position of the MODE switch) until it is the same as that of the one obtained directly from the camera.

Finally, record several minutes worth of your test picture and then play it back with the MODE control in the RECEIVE position. Adjust the WIDTH trimmer, R143, until the picture just fills the square display area. It should have the same height and width as the picture viewed in the CAMERA mode.

Remove the jumper from the PICTURE switch and you've completed the Picture Phone calibration, and are ready to put your unit to use.

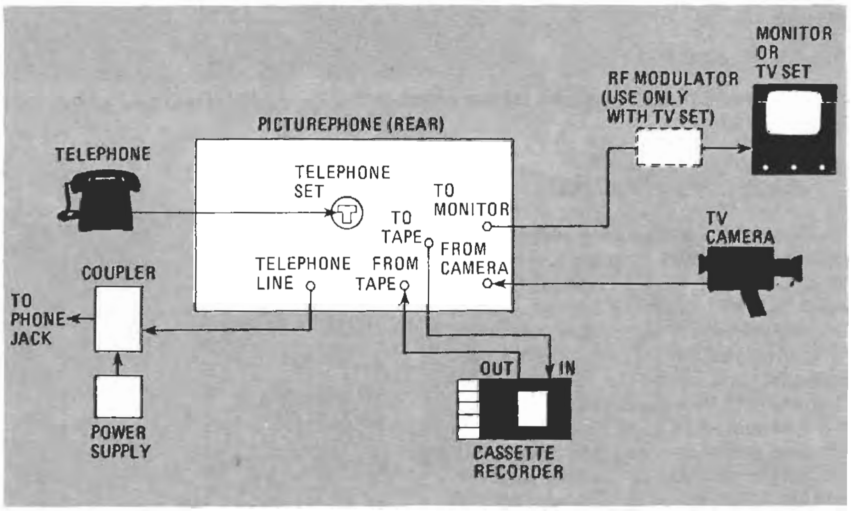


FIG. 22—CONNECTIONS TO AND FROM the Picture Phone. Be sure to use shielded cable to keep signals clean.

OOOOOOPS

In the schematic of the main board of the Picture Phone (Fig. 2, August 1982), capacitor C208 appeared twice. The C208 with a value of .001µF (near R139) should be omitted, as should its ground. In the Parts List (page 50, September 1982), resistor R81 *is* used—its value is 1000 ohms. Resistors R82—R84 are not used.

Troubleshooting

The preceding assumed that your Picture Phone operated properly the first time you turned it on. It is quite possible—due to the complexity of the device—that it did not and the following may help you to set things right.

First, check for all the things you would normally look for if something you built didn't work. Check your solder joints—both on the PC boards and the chassis wiring— and make sure that all the wires run to and from the points they're supposed to. Also make sure that all the IC's and other polarized components are installed properly and that all the IC's are in the sockets they're supposed to be in. Don't forget to check for IC pins that may have gotten bent under when you were inserting them into their sockets.

You can tell whether your unit is outputting slow scan by grabbing a frame, setting the MODE switch to TRANSMIT, and connecting an earphone to the TO TAPE jack. You should hear a sort of burbling sound that's very difficult to describe in writing but which you'll soon become familiar with. If you hear a steady tone, something's wrong; start checking back from the slow-scan audio-output stage.

If everything you've built looks all right, but you're still not getting results, it's time to get an oscilloscope and start signal tracing. It's not enough to verify that all the clocking and control signals are present—they must also be at the proper logic-levels. In the unit I built, I found that an off-value resistor had caused the biasing of one of the 1458 op-amps to be off, and the logic-level signals it was passing were shifted to the extent that the following TTL IC's could not recognize them. Use a logic probe, if necessary, to verify that you are getting true logic-highs and logic-lows.

While IC's are normally the last things you should blame for your problems, brand-new ones do tend to have an "infant mortality" rate of about one percent and, in a device with as many IC's as the Picture Phone has, there is a chance that one of them is bad. So, if a signal goes into an IC but doesn't come out, try

continued on page 112

PICTURE PHONE

continued from page 50

replacing that IC. You may solve your problem as easily as that.

If you find that you have vertical "barber pole" stripes breaking up the picture that is stored in memory, check IC66, the 3245 memory driver; one of its sections may be bad. And, finally, if you find that a picture stored in memory starts to develop "freckles"—dark or bright pixels appearing one by one until the overall quality of the picture starts to deteriorate, try substituting standard 74157's in place of the "LS" versions for IC's 5, 21, 37, and 53.

That covers only a few of the many things that may keep your Picture Phone from working the first time you apply power, but, if you persevere, you'll locate the problem area(s) and wind up with a first-class device.

Setup

Figure 22 shows how the Picture Phone is to be connected to its associated equipment. Remember that the video output of the unit is intended for use with a monitor;

if you use a TV receiver you'll need an RF modulator—those are readily available from most computer stores, or by mail from a number of advertisers in **Radio-Electronics.**

The most imporant factor in transmitting a good picture is good lighting; avoid hot spots and deep shadows. Try not to use a very light or very dark background—such a background may confuse the TV camera's ALC (*A*utomatic *L*ight *C*ontrol).

You can put the MODE switch in the CAMERA position to compose your picture, watching it on the monitor. The front panel BRIGHTNESS and CONTRAST controls will help give you the best-balanced image. To see what you will be transmitting, grab a frame from the camera and switch to the TRANSMIT or HOLD mode (you can grab a frame while in TRANSMIT).

Use

To use the Picture Phone, first place the phone call as you normally would to the other party. The Picture Phone can be on or off at this time, although you'll probably want it on so you can set up your pictures while you're talking. The until will come up in the VOICE mode when you apply power.

When you're ready to transmit slow-scan, grab a frame and inform the party at the other end of the line that you're ready to send video. Then turn the MODE switch to TRANSMIT and push the PICTURE button. That will disconnect the telephone handset from the line and connect in its place the output of the Picture Phone (you don't want your speech mixing with the slow-scan audio).

Every eight seconds you'll see the picture on your video display blink. That indicates that a frame has been completed. If you're in the MANUAL mode, the same frame will be repeated; if you're in the AUTOMATIC mode a new frame will be grabbed. The best time to switch back to VOICE mode is immediately after the finish of a frame. It's good practice to send more than one frame of each picture. Two are good; three may be better under some conditions.

When it's time for you to be on the receiving end, the other party will, of course, inform you that he or she is about to transmit video. Set the MODE switch to RECEIVE and press the PICTURE button. The slow-scan image will start forming from top to bottom, and will be complete in eight seconds. If you want to study a picture at leisure, use the HOLD position. If you do that, any further incoming video will be ignored, and you will be able to watch the same frame for as long as you like.

It may take a little practice to get the hang of using the Picture Phone, but, once you do, your personal and business telephone conversations will become tremendously richer. **R-E**

Picture Phone

Before you build your Picture Phone, you should know how the device works. We'll conclude our discussion of that topic in this part.

JOSEF BERNARD,
TECHNICAL EDITOR

Part 2 THE FIRST PART OF THIS article discussed the theory of operation of a good portion of the main board of the Picture Phone. We'll now complete that discussion; it will be helpful if you have Part 1 handy.

Fast-scan counters

The fast-scan counters are IC6, IC8, IC23 and IC39. Each IC is a four-stage binary counter that is cleared to all zeroes when pin 1 is taken to a logic-low state. When pin 9 is low, the counter stages are preset to the value hard-wired at pins 3-6. Pin 2 receives the clock pulses, and responds to their positive-going edges. Both clear and load operations are synchronous—that is, they take place only on the positive-going edge of the clock pulse. When the LOAD or CLEAR pin is taken low, the counter stops and retains its value. If a clock pulse occurs while the appropriate pin is low, the counter will load or clear.

The fast-scan dot counters are IC6 and IC8 (dots are the pixels along a line of video). The dot counter is analogous to the horizontal sweep in the camera and display. The dot counters have two modes, one for the camera and one for all other operations.

Let's consider non-camera operation first. The crystal oscillator supplies clock pulses to pin 2 of the dot counters. Note that pin 15 of IC6 is connected to pin 10 of IC8. That is the "carry" from the first IC to the second, and provides synchronous operation of both IC's.

Figure 5 shows the timing of the dot counters. The counter CLEAR pulse is provided by IC10 at a count of 215. That means that the counter advances to 215, is reset to zero, and begins to count again. The internal horizontal-sync pulse (IFH) is produced by counter inputs applied to IC42. The clock frequency, divided by 216 (the count from zero to 215), generates the correct horizontal-sync frequency.

Signal "J," which is low between the counts of zero and 127, serves several purposes. It is delayed by one clock pulse to form IFHB, the internal fast-scan blanking signal, which blanks the display in all modes. That signal is also applied to IC28 to control when data can be written to memory. Memory-write takes place, and the display is unblanked, when the counter is between zero and 127.

Now let's look at the operation of the dot counter in the "snatch" and camera-display modes. The clocking signal is derived from the synchronous oscillator; and IC10, which supplies the CLEAR pulse, is disabled. The counter advances until a horizontal-sync pulse from the camera (EFH) takes the LOAD pin low. The counter is preset to a value of 217, as determined by the fixed inputs to pins 3-6 of IC6 and IC8. The counter resumes counting at a preset value of 217 when EFH is no longer present. When it reaches its maximum count of 255, it resets to zero and starts counting again. The time spent counting from 217 to 255 represents blanking of the left-hand edge of the picture; the time between 128 and EFH is used for right-hand blanking.

The LOAD pin is controlled by an RS flip-flop made from IC15-c and IC15-d. That flip-flop insures that the LOAD pin remains low until a clock pulse to load the counter has arrived.

The EFH signal is applied to the CLEAR pin of IC32 to insure that the clock always starts with the same polarity.

The fast-scan *line* counters are IC23 and IC39. Let's first look at how they work during the non-camera mode. Dot-counter signal "J" is used as the clock pulse, making the line counter advance one step for each line. Nine count-stages are needed; the extra stage is supplied by IC32 and is the least significant bit.

Figure 6 shows that the counter advances to a count of 262, is cleared, and starts again at zero. The clear pulse is supplied by IC47, which is hard-wired with the eight most-significant bits of the line counter. The CLEAR pin is held inactive when the camera is in use by connecting it to the logic-1 present at pin 10 of IC48.

The internal fast-scan vertical sync (IFV) comes from IC31.

When the camera display is viewed, the CLEAR function is disabled and the line counter is preset whenever a vertical-sync pulse occurrs. When the counter is preset and the sync pulse from the camera is completed, the counter starts counting. When the count reaches 511, the next count, zero, allows display and writing to memory to begin. The time that is spent in counting from the preset value to zero is used to allow the camera's blanking-function to be completed.

The line counter advances two counts for each slow-scan line to allow each line to be displayed twice for an easier-to-view picture. There are 128 slow-scan lines, which means that 256 lines-per-field (or 512 lines-per-frame) will be displayed. Since NTSC standards call for 525 lines per frame, a small portion of the picture at the top and bottom is blanked.

Slow-scan clocks

There are two slow-scan clocks. One is derived from the master crystal oscillator and is used for all functions except slow-scan reception. The second clock is free-running, and is synchronized to the slow-scan horizontal-sync pulses. The clocks are selected by IC13, a 4PDT multiplexer.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise noted

R1-R3, R43, R78, R139, R202—22,000 ohms
R4, R201—10 megohms
R5, R6, R8, R9, R50, R80—15,000 ohms
R7—620 ohms
R10, R12, R15, R54, R93-R95, R102, R110, R209, R211, R714-R716—4700 ohms
R11, R13, R14, R16-R18, R86, R99—10,000 ohms, 1%
R19, R20, R27, R147—39,000 ohms
R21—20,000 ohms
R22, R23—18,000 ohms
R24—8200 ohms
R25, R26, R145, R146—82,000 ohms
R28, R42, R51, R136, R140, R142, R204, R205, R710, R711—10,000 ohms
R29—470,000 ohms
R30, R47-R49, R53—2200 ohms
R31, R79, R148—100,000 ohms
R32, R108—2700 ohms
R33—150,000 ohms
R34, R40, R52, R96, R109, R137, R144, R704, R717—1000 ohms
R35-R39—not used
R41—680,000 ohms
R44—47,000 ohms
R46—33,000 ohms
R55, R76, R112, R707—100 ohms
R56—100 ohms, trimmer potentiometer
R57—3300 ohms
R58, R77, R111—330 ohms
R59, R703, R712, R713—470 ohms
R60—100 ohms, 1%
R61-R75—26.1 ohms, 1%
R81-R84—not used
R85, R98—20,000 ohms, 1%
R87, R100—4990 ohms, 1%
R88, R101—2490 ohms, 1%
R89-R91—not used
R92, R200—680 ohms
R97—47 ohms
R103—820 ohms
R104—2000 ohms, trimmer potentiometer
R105—1200 ohms
R106, R107, R138, R141, R143, R203—1000 ohms, trimmer potentiometer
F113-R116, R125-R135—33 ohms
R117-R123—not used
R144—68,000 ohms
R149-R199—not used
R206, R207—220 ohms
R210—560 ohms
R212, R213—33.2 ohms, 1%
R314, R315, R317, R318—0.33 ohms, 2 watts
R316—220 ohms, 2 watts
R601—130 ohms, 2 watts
R701—1000 ohms, panel-mount potentiometer
R702—10,000 ohms, panel-mount potentiometer
R706—1 megohm
R708, R709—1800 ohms, 1 watt

All capacitors Mylar or mica unless otherwise specified

C1-C6—.022μF
C7, C24, C25, C38, C200, C240-C243—.01 μF ceramic disc
C8, C10, C12, C17—.0047 μF
C9—.0068 μF
C11, C207—.018 μF
C13, C15, C18, C19, C23, C263-C266—22 μF, tantalum
C14—10 μF, tantalum
C16, C22, C206, C703—.001 μF, monolithic or ceramic disc
C20, C201—27 pF, monolithic or ceramic disc
C21, C28-C31—470 pF
C26—not used
C27—33 pF, monolithic or ceramic disc
C32, C220-C227—0.1 μF, ceramic disc
C33, C41, C208, C317-C320—2.2 μF, tantalum
C34, C230-C237, C250-C262, C702—0.1 μF, ceramic disc
C35, C202-C205—100 pF
C37, C39—not used
C40—.047 μF
C309—500 μF, 12 volts, electrolytic
C310—9200 μF, 15 volts, electrolytic
C311—450 μF, 25 volts, electrolytic
C312—5800 μF, 25 volts, electrolytic
C601—500 μF, 25 volts, electrolytic
C701—2 μF, tantalum

Semiconductors

IC1-IC4, IC17-IC20, IC33-IC36, IC49-IC52—μPD411 (MM5280) 4K × 1 dynamic RAM
IC5, IC13, IC21, IC37, IC46, IC48, IC55—74LS157 quad 2-1 multiplexer
IC6, IC8, IC9, IC23, IC24, IC39-IC41—74LS163 presettable binary counter W/clear
IC7, IC26, IC57, IC58, IC61—75LS04 hex inverter
IC10, IC31, IC47—74LS30 8-input NAND gate
IC11, IC32—74LS107 dual JK negative-edge-trigger flip-flop
IC12—4046 CMOS phase-locked loop
IC14, IC15, IC45—74LS00 quad 2-input NAND gate
IC16, IC29, IC65—74LS74 dual D flip-flop
IC22, IC38, IC71, IC72—74LS153 dual 4-input multiplexer
IC25, IC42, IC88—74LS20 dual 4-input NAND gate
IC27, IC67, IC68—74LS10 triple 3-unit NAND gate
IC28, IC43, IC66—74LS25 dual 4-input NOR gate
IC30—74LS221 dual one-shot
IC44, IC62—74LS32 quad 2-input positive OR gate
IC54, IC56—74LS175 quad D flip-flop
IC59—74LS08 quad 2-input AND gate
IC60, IC63, IC64—74LS13 dual Schmitt trigger
IC66—3245 quad TTL-to-NMOS memory driver
IC69, IC70—74LS02 quad 2-input NOR gate
IC73-IC80—LM711 dual difference-comparator
IC81-IC84—not used
IC85, IC86—74LS86 quad EXCLUSIVE-OR gate
IC87—4066 CMOS quad bilateral switch
IC89—566 function generator
IC90-IC94, IC105—1458 dual 741 op-amp
IC95-IC104—not used
Q1, Q2, Q4, Q5, Q8-Q13—2N4124 or equivalent
Q3, Q6—not used
Q7—2N4126 or equivalent
LED1-LED3—jumbo red LED
D1-D11, D13-D18, D27-D33—1N914 or 1N4148
D12—not used
D19-D26, D601, D602—1N4007
DT601—gas discharge tube (Joslyn Electronics type 2022-44 or equivalent)
CB1—0.6-amp circuit breaker
T1—dual-secondary type: 1st secondary: 25VCT, 1 amp; 2nd secondary: 12.6VCT, 1.5 amps (see text and below)
T601—phone-line matching transformer (Microtran type 6112 or equivalent)
S1—4P5T rotary switch
S2-S4—N.O. momentary pushbutton switch
S5—SPDT toggle switch
S6—SPST toggle switch
J1-J2—not used
J3—36/72-pin PC-board edge connector (36 contacts for *each side* of board, two contacts per pin)
J4—socket for modular telephone connector, panel-mount
J5—DB25-S 25-pin female "date-type" socket, panel-mount
J6, J7—RCA-type phone jack, panel-mount
J8, J9—female coaxial connector, panel-mount (BNC- or SO230-type)
TB601—miniature 8-terminal barrier strip, PC-mount
RY601, RY602—4P2T 12-volts, PC-mount (Potter & Brumfield T10-E2-Z4-12VDC or equivalent)

Miscellaneous: PC boards, perforated construction board, IC sockets, RG59 cable, shielded audio cable, 4-conductor telephone cable w/modular plug, 3-conductor line cord w/plug, enclosure, hardware, etc.

The following are available from Robot Research Inc., 7591 Convoy Court, San Diego, CA 92111, (714) 279-9430: Assembled & tested Model 535 Picture Phone, FCC registered for direct connection to telephone line (KIT-1) (14 lbs.), $1195.00; assembled and tested No. 400929C main PC board (KIT-2) (4 lbs.), $495.00; assembled and tested Picture Phone chassis, including telephone adaptor board, but *less main board,* (KIT-3) (12 lbs.), $695.00; kit of No. 400929C main PC board with all main-board parts (KIT-4) (5 lbs.), $295.00; kit including chassis and chassis parts, and telephone adaptor board and parts, but *less main board,* (KIT-5) (12 lbs.), $445.00; telephone adaptor board kit including board and parts (KIT-6) (3 lbs.), $79.50; etched, drilled, and plated-through main board (KIT-7) (3 lbs.), $59.00; etched, drilled, and plated-through telephone adaptor board (KIT-8) (2 lbs.), $19.95; T1 (KIT-9) (4 lbs.), $29.50; T601 (KIT-10) (2 lbs.), $24.50; DT1 (KIT-11) (1 lb.), $8.50; kit of 32 1% resistors for main board (KIT-12) (1 lb.), $12.00; individual 1% resistor (KIT-13) (1 lb.), $0.35; Model 535 Picture Phone enclosure kit with mounting rails for main board and back plate for controls (KIT-14) (6 lbs.), $99.50; kit of *front panel parts only,* (KIT-15) (2 lbs.), $59.50; assembled & tested RF modulator, less power supply and enclosure (KIT-16) (1 lb.), $29.00; RF-modulator kit, less power supply and enclosure (KIT-17) (1 lb.), $19.50. For information on other parts, write to Robot Research.

CA residents please add 6% sales tax. All prices F.O.B. San Diego—check with UPS for shipping charges; please add $0.50 per $100.00 of value above first $100.00 for insurance. MC and Visa accepted.

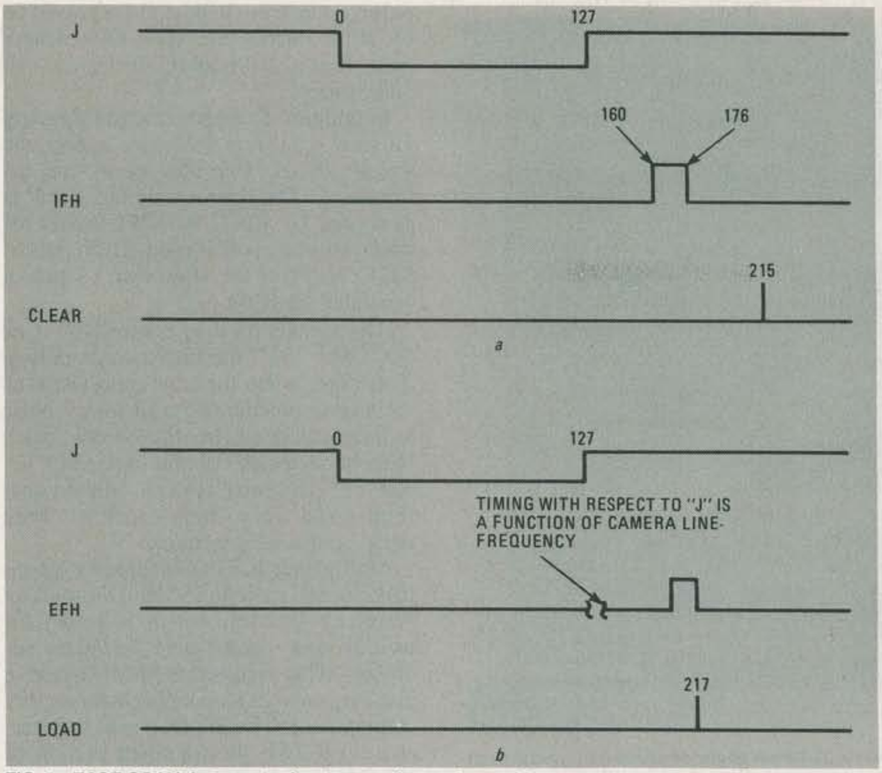


FIG. 5—FAST-SCAN dot counter has two modes—*a* is used for memory display, *b* for frame grabbing and camera display.

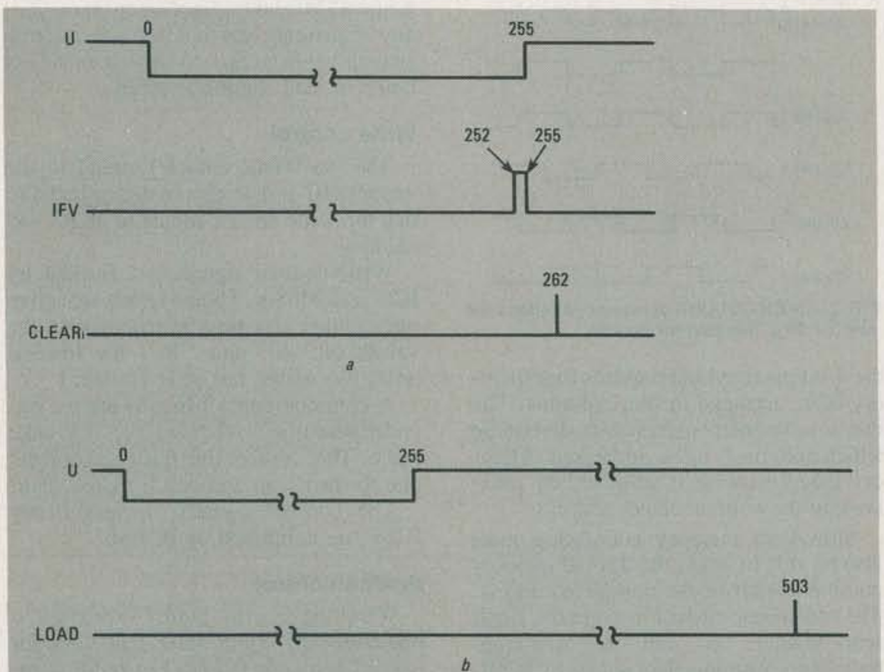


FIG. 6—FAST-SCAN line counter timing for memory display (*a*), and camera display (*b*).

The crystal-derived clock pulses begin with the 60-Hz "U" output of the fast-scan counter. It is divided by four by IC11. The resulting 15-Hz pulse train is applied to one input of PLL (*P*hase-*L*ocked *L*oop) IC12. The other input to that IC is the clock oscillator's output divided by 139, making the output of the PLL 15 × 139, or 2085 Hz. That becomes the slow-scan clock. It allows for 128 pixels and 11 sync counts per slow-scan line.

The synchronized clock pulses are generated by IC60. Its free-running frequency is controlled by R143. As the frequency is increased, the counter takes less time to address 128 memory "cells" and a shorter line is displayed. The clock is synchronized with the incoming signal by having the incoming slow-scan sync pulses cause the oscillator to stop and restart in phase with them.

The slow-scan clock is aligned with the fast-scan system by retiming the leading and training edges of the clock pulses with a section of IC16. A control signal,

CAUTION:

FCC regulations prohibit the connection of this device to telephone lines without the use of an approved coupling device. The *only* exception to this is the assembled and tested unit available from the suppliers indicated in the Parts List. A coupler that meets FCC requirements will be described in the next part of this article. *Do not attempt to connect the Picture Phone you build without it—it's illegal to do so.*

"Z," controls all the slow-scan functions. It is in operation only for the duration of the slow-scan memory-write cycle. Its use for retiming the slow-scan insures that the clock will not change during a slow-scan read or write memory access.

Slow-scan counters

The slow-scan counter is made up of IC9, IC24, IC40 and IC41. They function the same way as their counterparts in the fast-scan circuit.

The slow-scan dot counter uses IC9 and IC24. It has two modes of operation—one to write slow scan to memory, and one to read it. Let's look at the read-mode first. The clock signal is derived from the crystal oscillator. The CLEAR signal is derived from IC25; the LOAD function is inactive. The counter is cleared at a count of 139 to provide 128 memory "cells" per line and 11 sync counts.

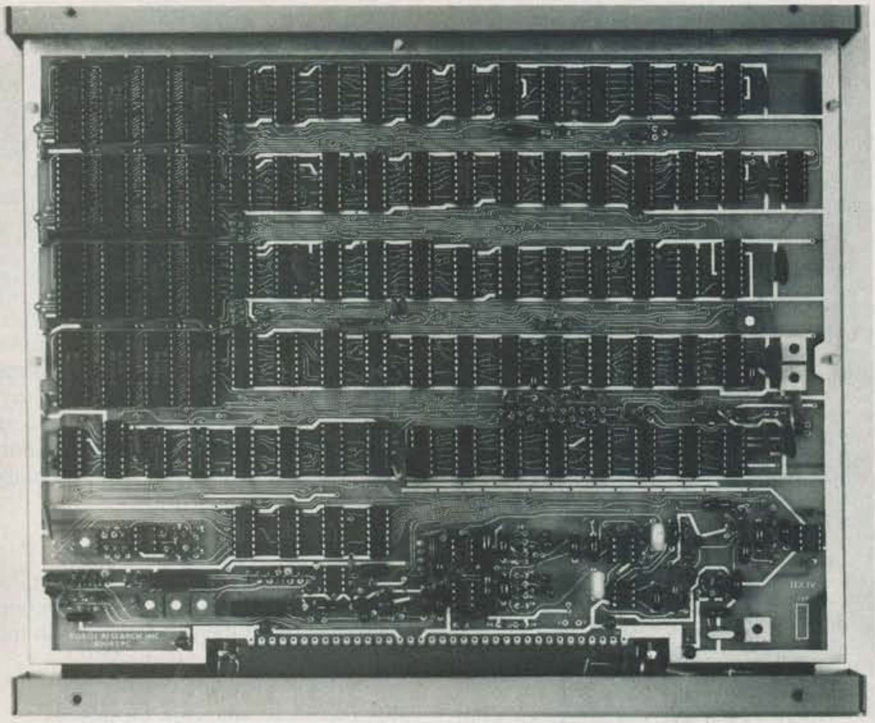
When slow scan information is to be written to memory, the free-running clock is used. The CLEAR signal is derived from a flip-flop formed from IC14-a and IC14-b. The flip-flop is set by an incoming sync pulse, and reset by a clock pulse. That is done to make sure that a clock pulse to clear the counter occurs while the CLEAR pin is low. The slow-scan sync pulse is allowed to reset the counter only after 128 counts (the end of a line) to insure noise immunity. In other words, false pulses can't interrupt a line as it is being written.

The line counter uses IC40 and IC41. A clock pulse occurs when each slow-scan line has been completed. The counter is reset to zero in the "read" mode at a count of 127 by the "U" signal. In the "write" mode it is cleared by the external vertical-sync signal applied to an RS flip-flop made from IC14-c and IC14-d. The flip-flop is reset by IC43 and IC45-a.

When a picture is grabbed from the camera, the line counter is set to all ones, and on the next clock pulse to all zeroes. That one-line time generates a slow-scan vertical-sync pulse.

Address selector

The memory address-lines are driven by the fast-scan counter to generate a video signal for fast-scan display, and also by the slow-scan counter to generate a slow-scan signal. The memory address-



COMPLETED MAIN BOARD of the Picture Phone plugs into 36/72-pin edge connector mounted at front of enclosure.

lines are connected to the appropriate counter by an address multiplexer made up of IC5, IC21 and IC37—4PDT switches, each of which switches four address lines. Resistors on the leads to the memory IC's damp reflections so that the address voltages will not ring.

The address lines are in the "slow scan" mode during time "Z," which takes place for 16 dots following the right-hand edge of the fast-scan picture. In other words, slow-scan memory access takes place just after fast-scan access for the current line is completed. When "Z" becomes active, the address multiplexer switches to slow scan, and the slow-scan counter is inhibited from changing state. The "Z" signal is generated by IC25-b.

Fast-scan memory multiplex

To obtain the speed required for fast-scan operation, memory operation is multiplexed. The multiplexing is done with the memory CE (*C*hip *E*nable) pulse. Figure 7 shows the CE pattern. Note that successive memory columns are overlapped by 50%.

The CE signal is formed by a delay flip-flop, IC65, that uses "B" as data and "A" (delayed) as a clock signal. Signal "A" is delayed by an RC circuit that feeds Schmitt trigger IC60. The delay is provided to insure that memory address-lines are stable before CE goes high.

The CE signal is a zero-to- + 12-volt pulse translated from 5-volts by IC66.

Slow-scan memory multiplex

Memory multiplexing is performed by the two lowest-order bits on the memory address-lines. In other words, each bit of the 4-bit pixel nybble requires four memory IC's, arranged in four columns. The two lowest-order address bits determine which column is to be addressed. Memory-speed increase is achieved by overlapping the column-select address.

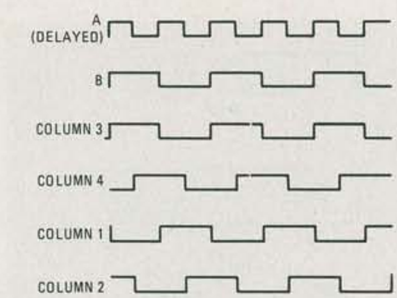


FIG. 7—EACH COLUMN of memory overlaps the next by 50%. See text for details.

Slow-scan memory addressing must also be able to select the desired memory column as part of the complete address. The two lowest-order bits from the slow-scan counter, "a" and "b," are combined into column-select pulses by IC69.

Each of the 16 memory IC's has a CS (*C*hip *S*elect) pin that is used for slow-scan memory column selections. The CS pulses come from IC69 and are passed on by IC70 during the slow-scan access time. That IC holds all IC's selected at all other times.

REAR PANEL of Picture Phone. Circuit-breaker reset is located above line cord at left.

In addition to addressing the memory for slow scan, it is necessary to time the storage of the incoming slow-scan information. The required timing signal is generated by IC71, a DP4T switch of which only one pole is used. The inputs of IC71 consist of the slow-scan CS pulses generated by IC69.

The signals used to control IC71 are "X" and "Y," the fast-scan CS pulses. Therefore, when the slow- and fast-scan CS pulses coincide, a "read store" pulse will be generated. In other words, when IC69 has selected column one, and "X" and "Y" have also selected column one, then—and only then—will a "read store" pulse be generated.

Multiplexer IC71 is enabled by a control signal called SSME (*S*low-*S*can *M*emeory *E*nable), which is active for exactly four consecutive fast-scan addresses. That means that SSME is active just long enough to sample each memory column once. The SSME signal is generated by IC27-b. It is a small portion of "Z," which is the time for slow-scan address to be applied to the memory. Since SSME takes place later than "Z," any transients created by the address switchover from fast- to slow-scan die out before a read sample is taken.

Write control

The WE (*W*rite *E*nable) signal to the memory IC's must also be multiplexed so that the write and CE inputs to an IC will coincide.

Write-control signals are formed by IC67 and IC68-b. Those signals are active one column at a time in response to the values of "A" and "B," the lowest-order bits of the fast-scan counter.

A common control-line to the WE encoder determines when writing is to take place. That control line has two sourses, one for fast scan and one for slow scan.

The control signals, generated by IC28, are combined by IC44-b.

Snatch control

When the SNATCH button is pressed, a one-shot puts out a pulse that lasts for several fast-scan fields. The pulse is retimed by a section of delay flip-flop IC29 so that the useful SNATCH command starts and ends at the bottom of a TV picture. That prevents any errors that might result from the SNATCH pulse ending in the middle of a picture. Another section of IC29 retimes display selection so that the changeover between display memory and the camera takes place when the picture is blanked.

In the next part of this article we'll discuss the telephone interface and power-supply circuits. We will also begin to look at the construction and alignment of the device. **R-E**

Picture Phone

The telephone adaptor board, the power supply, and construction of the device are the topics covered in this month's look at the Picture Phone.

JOSEF BERNARD,
TECHNICAL EDITOR

Part 3 THE FIRST TWO PARTS of this article discussed the theory of operation of the main board of the Picture Phone. We'll now describe the telephone adaptor board and power supply. We'll also begin to look at the construction of the device. As always, it will be helpful to have the previous parts of this article as we proceed.

Telephone adaptor board

The telephone adaptor board, shown in Fig. 8, serves two purposes: it serves as an interface between the main board and the telephone line, and also allows the user to switch between VOICE and PICTURE modes.

Transformer T601 provides impedance matching between the main board and the telephone line's 600-ohm requirements. It also provides electrical isolation between the phone line and the Picture Phone. The transformer contains a grounded electrostatic shield (indicated by the dashed line) to reduce hum. Additional protection to the phone line is provided by a static-discharge device, DT1.

It must be noted that, while those precautions should provide sufficient protection to satisfy your telephone company's requirements for connecting non-company equipment to its lines, the Picture Phone *must* be used with a coupling device approved by the phone company.

The Picture Phone is connected to the phone line by a standard four-conducter phone cable terminated in a modular phone plug. A modular jack on the rear of the Picture Phone cabinet accepts the plug from an ordinary telephone. The telephone can be used normally when the Picture Phone is off or when it is in the VOICE mode. Connections between the modular jack and the adaptor board are made through an 8-terminal barrier strip, TB601.

The second function of the telephone adaptor board is to provide switching between VOICE and PICTURE modes. Two relays, RY601 and RY602 provide that function. They are controlled by pushbuttons S2 and S3 on the front panel. When turned on, the Picture Phone "comes up" in the VOICE mode and the telephone can be used normally. When the PICTURE switch is depressed, though, several things happen.

First, the telephone is disconnected from the line. Usually, that would cause the phone company's equipment to "think" that you had hung up, and disconnect you. The Picture Phone, however, through relay R601, provides a "holding voltage" which, as far as the phone-company equipment is concerned, means that the phone is still off the hook, and the connection is maintained.

With the telephone out of the circuit, audio is routed to and from the main board of the Picture Phone in the form of a slow-scan video signal, composed of tones ranging from 1500 Hz to 2300 Hz (see Part 1). The mode switch, S1, in the center of the front panel determines whether the slow-scan audio will be transmitted or received.

When the PICTURE switch is pushed, the relays latch, and the Picture Phone remains in the PICTURE mode until the VOICE button is pushed.

Associated with those two switches are LED2 and LED3, which indicate the current status of the device.

Power supply

The Picture Phone requires five working voltages: plus-and-minus five volts DC, plus-and-minus 12 volts DC, and −20 volts DC. The power-supply schematic is shown in Fig. 9. While a single transformer with two secondaries can be used to obtain all those voltages, it may be difficult to locate; such a transformer is available from the supplier indicated in the Parts List (see last month's issue).

You may, however, choose to use two transformers. Both should be center-tapped. The first should be capable of supplying about 12.6 volts *on each side* of the center tap, for a total of about 25 volts at one amp. The second transformer should be capable of supplying about 6.3 volts on either side of the center tap, for a total of 12.6 volts at 1.5 amps.

Standard bridge-rectifier/capacitor circuits are used, along with tab-type regulators to obtain the final working voltages. The −20 volts is taken from the *input* to the −12-volt regulator. A 0.6-amp circuit breaker, CB1, is used for protection.

The output of the +5-volt supply is used to drive LED1, the POWER indicator mounted on the front panel.

Front-panel controls

The functions of some of the front-panel controls have already been explained; this is what the others do:

Snatch button (unlabelled), S4, is used when you wish to "grab" a frame of video to be transmitted. It is active only when S5, the MANUAL/AUTOMATIC switch is in the MANUAL position. When S5 is in the AUTOMATIC position, a new frame will be snatched automatically every eight seconds.

The BRIGHTNESS and CONTRAST controls, R307 and R305, control the quality of the image that you are transmitting. (There will be more about them in the section on using the Picture Phone.) It is assumed that the party with whom you are exchanging video is sending a good quality picture, so no external controls are

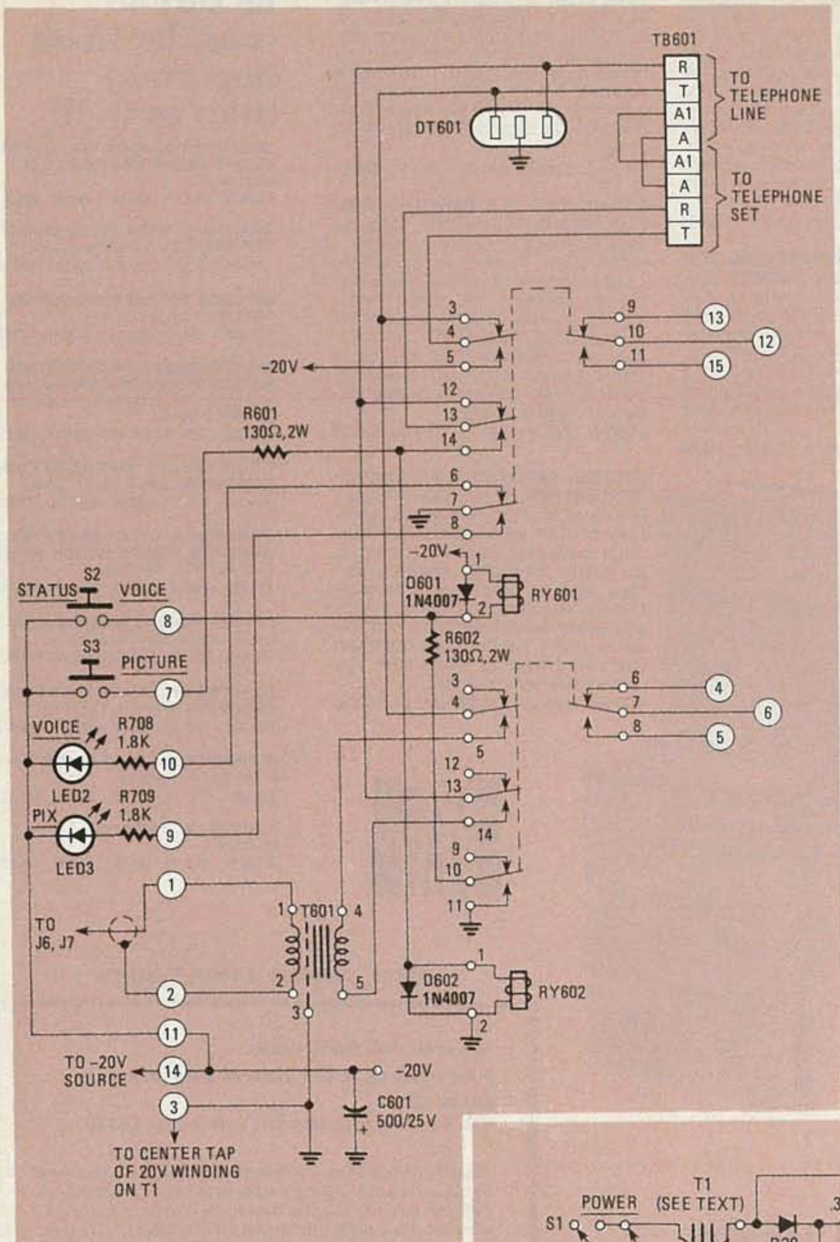


FIG. 8—TELEPHONE ADAPTOR BOARD provides switching and impedance-matching functions, and also controls status indicators.

provided for RECEIVE adjustments.

The final control that needs explaining is the five-position mode switch, S1. In its fully-counterclockwise position, GRAY SCALE, it loads a four-level gray scale into memory for calibration purposes. The next position, CAMERA, allows you to view a real-time digitzied image from your camera on your monitor. That permits both focusing and composition, as well as allowing you to set the BRIGHTNESS and CONTRAST controls for best results.

The TRANSMIT position is used when you are in the PICTURE mode to transmit the video stored in the Picture Phone's memory. The next position, HOLD freezes a frame of received or transmitted video in memory and displays it indefinitely, regardless of whether new video is available or not. It is particularly useful if you want to be able to look at a received image while discussing it in the VOICE mode.

Finally, the function of the RECEIVE position should be obvious—it loads video into the Picture Phone's memory for display on your monitor.

There is one connector on the rear of the cabinet that should be explained. That is a 25-pin DB25-S socket of the type used on computer equipment. It can be used for the connection of remote switches for SNATCH, VOICE/PICTURE, etc.

Construction

Construction of the Picture Phone can be divided into two parts—the three boards (main, phone adaptor, and power supply)—and chassis wiring. It's probably best to complete the first two boards first, and then combine the power-supply board and chassis wiring.

Because of the large size and complexity of the double-sided main board (almost 10 × 12 inches) it is impractical to reproduce foil patterns for it here with clarity. If you want to try to make your own board (it's available from the supplier indicated in the Parts List), full-sized printed (*not* film) positives can be obtained by sending $1.50—along with a note indicating that you want the foil patterns for the board *and* the address to which they are to be sent—to: Picture Phone, **Radio-Electronics,** 200 Park Avenue South, New York, NY 10003.

The parts-placement diagram for the main board is shown in Fig. 10; refer also to Fig. 11. Assembly of the board is straightforward, and should present little difficulty as long as you proceed with care. Don't rush the job, for that is sure to

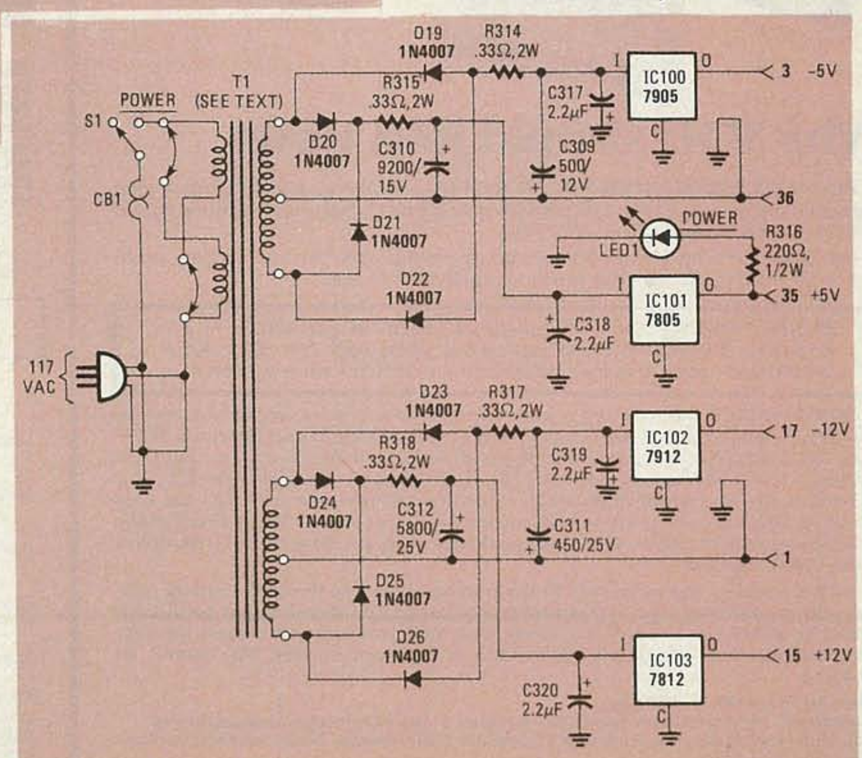


FIG. 9—POWER SUPPLY provides ±12 volts, ±5 volts, and -20 volts. See text and Parts List (in last month's issue) for T1 information.

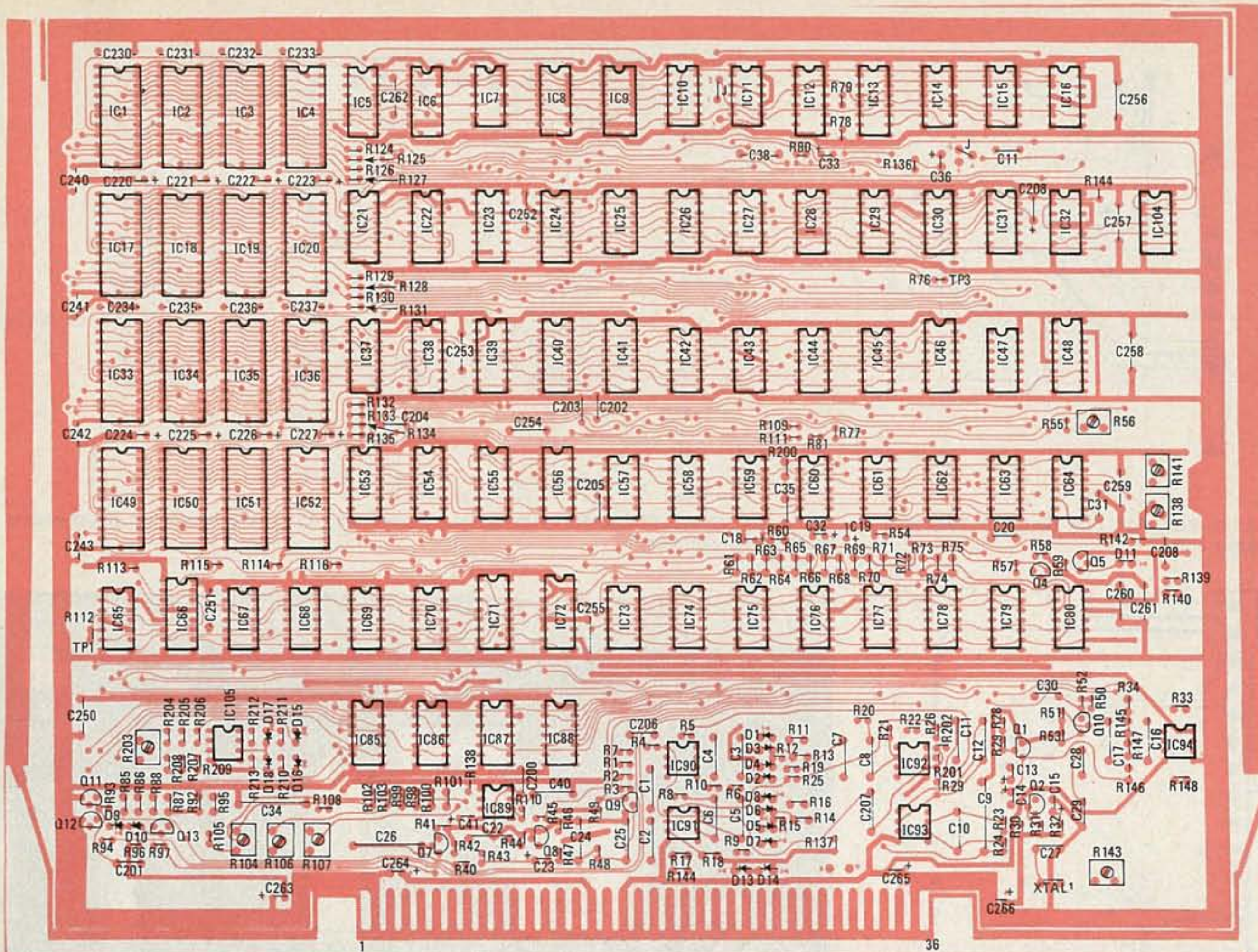


FIG. 10—ALL IC's face in the same direction. Note that resistors and diodes are mounted vertically to conserve board space.

lead to problems, and it will be a long time before you solve them and have your Picture Phone operating.

It's best to insert all the IC sockets first (note that they all face in the same direction) and make sure that you *don't* insert 14-pin sockets where there should be 16-pin ones. Be sure that *all* the pins are soldered—with that many connections, it's easy to miss one, and you'll spend hours or days before you discover that one unsoldered socket-pin is the reason that the equipment isn't functioning.

Next install the resistors and diodes. Note that they are all mounted vertically (standing on end). Be extremely careful about the polarity of the diodes, and don't forget the two short jumpers. Finally, install the capacitors, again being careful to observe the polarities of the tantalum types. **Do not insert any IC's into their sockets yet.** When you're finished with the main board, set it aside temporarily and go on to the phone adaptor board.

That double-sided board, whose foil patterns are shown in Figs. 12 and 13, and parts-placement diagram in Fig. 14, is easy compared to the main board. The parts should slip right into the holes—just make sure that the electrolytic capacitor,

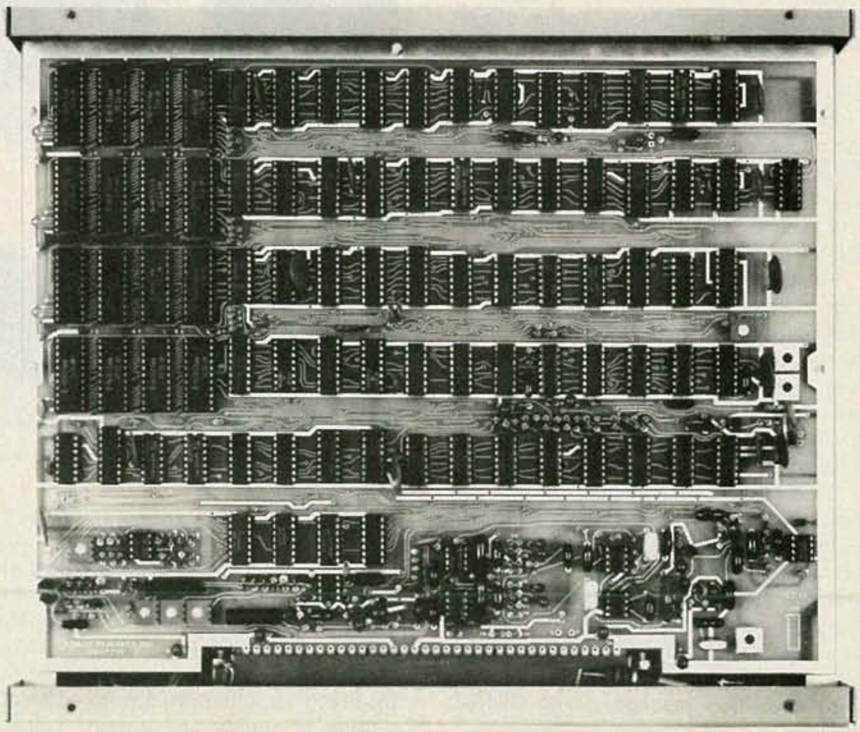


FIG. 11—THIS PHOTO shows how the main board should look when it is correctly assembled. It is shown here mounted in the enclosure.

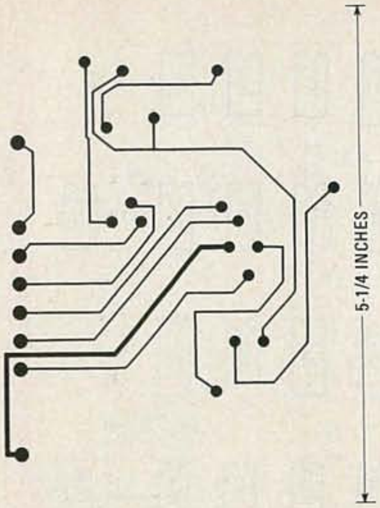


FIG. 12—FOIL PATTERN for top of telephone adaptor board.

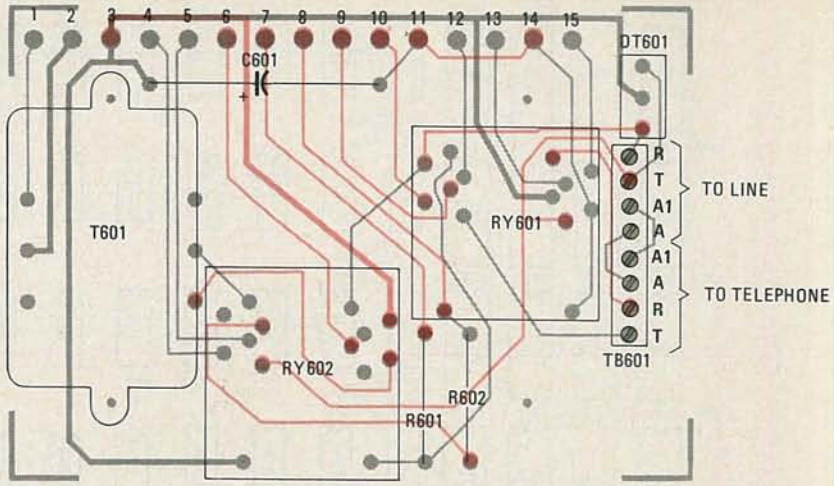


FIG. 14—USE SMALL PC-BOARD pin connectors at positions 1-15 to make it easier to connect wires to telephone adaptor board.

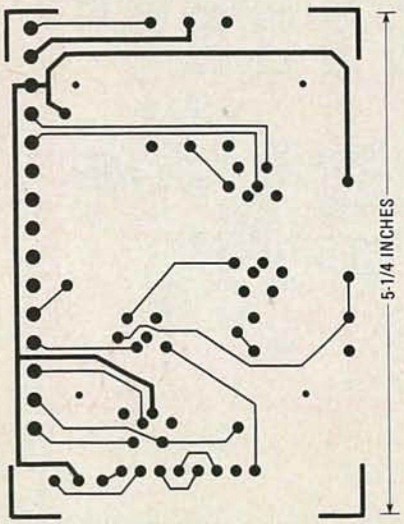


FIG. 13—FOIL PATTERN for bottom of telephone adaptor board.

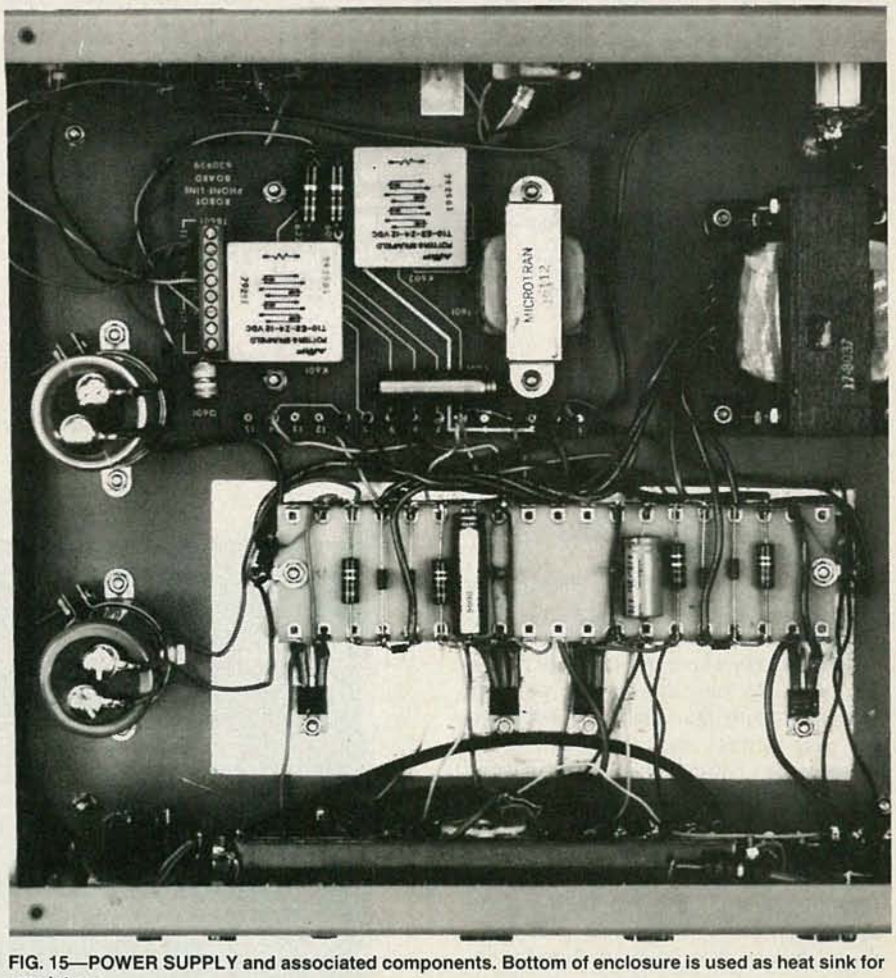


FIG. 15—POWER SUPPLY and associated components. Bottom of enclosure is used as heat sink for regulators.

C601, is oriented properly, and that the 8-terminal barrier strip is inserted so that the phone wires can be connected from the outside of the board. Using small PC-board pin-connectors at positions 1-15 will make it easier to make connections to the board later.

Most of the power supply, shown in Fig. 15, can be constructed on a piece of perforated construction board; the two large capacitors, C310 and C312, and the four regulators will be chassis-mounted and wired to the board. Be sure to allow for the many ground connections that will have to be made from that board.

The two off-board capacitors should be bracket-mounted to the chassis as shown in Fig. 15, and the regulators secured to the top side of the bottom of the case. Be sure that the tabs of the *positive* regulators make good electrical contact with the case, and be sure that the *negative* regulators are insulated from the case (use nylon hardware, mica insulators, and silicone grease).

When the three boards are complete, you can install the chassis-mounted components, such as the power transformer, switches, jacks, LED's, the two large capacitors, etc. It will probably be easier *not* to mount the 36/72-pin edge connector for the main board at this point, because doing so will make it awkward to make connections to it. You'll find that the liberal use of terminal strips will make routing of supply and control voltages more convenient.

Mount the power-supply board in the case first, using standoffs, and connect it to the two large capacitors and to the regulators. Use "spaghetti" on the leads of the regulators, as shown in Fig 15, for safety.

When we continue our look at the Picture Phone, we will finish up the construction of the device. We'll also look at how it is aligned as well as how it is used. Also covered will be how to connect it to the phone lines. **R-E**

PICTURE PHONE

Your Picture Phone should now be nearly complete. Here's how to finish it, calibrate it, set it up, and use it.

JOSEF BERNARD
TECHNICAL EDITOR

Part 4 BEFORE YOU CAN PUT your Picture Phone into service, you'll need to buy and install a telephone coupler. This month we'll look at those, and show you how to align and use your Picture Phone. But first, let's finish up the construction.

When running lines for the AC voltages, twist wires carrying similar voltages together; that will help reduce 60-Hz hum in the system. Also try to keep the wires as close to the chassis as possible, again to reduce hum.

Next, install the telephone adaptor board, again using standoffs. You can now proceed with the chassis wiring, shown in Fig. 16. It's a good idea to color-code your wires—red for +5 volts, blue for +12 volts, orange for control signals, etc. That will make wire-routing easier and also help you in troubleshooting, should that be required.

Aside from keeping things neat, perhaps the most difficult part of the chassis wiring is the MODE switch, S1. Make sure that all the diodes on the switch are oriented correctly, and be liberal with the "spaghetti" to prevent shorts. Thinning the braid of the shielded cables before twisting and tinning it may make it easier for it to fit through the switch lugs.

Note that the use of the DB25-S connector (see Fig. 17) is optional, but it's a good idea to install it in case you decide to use it later. Also, R710 (10K) is intended for use with tape recorders having a LINE or AUX input. If your recorder has only a MIC input, use a much higher value—at least several hundred kilohms.

Your last step should be to mount the edge connector for the PC board, again using standoffs. It should be at a level where the board can plug into it without touching the components below it. You will also have to provide a frame and bracket to support the sides and rear of the board. Figure 15 (see last month's issue) shows you how that can be done (note the nylon standoffs into which the board snaps).

Before plugging the PC board into the edge connector, turn the unit on and check to make sure that the right voltages appear at the right pins. If everything checks out, turn the power off, allow a couple of seconds for the capacitors to discharge (you can tell by watching the front-panel LED's), and then carefully insert the board into its connector.

Again, turn the power on and, this time, check for the proper voltages at the IC-sockets. An ordinary straight pin makes an ideal probe for the purpose—it will slip right into the socket hole you're checking. If everything looks OK, turn the power off and insert the IC's into their sockets.

Certain pins on IC23, IC31, and IC47 have to be disabled for timing purposes. That is done as shown in Fig. 18, by bending the unused pins up until they stick out at right angles to the others and cannot fit into the sockets.

An inexpensive coupler

Telephone couplers, sometimes known as wiring protectors, are required to prevent the possibility of damage to telephone-company equipment by devices (such as the Picture Phone you built) that have not been approved by, and registered with, the FCC. Unfortunately, homebrew equipment—even if built from a kit—cannot, at least, not easily—obtain FCC approval, and an approved coupler must be used.

There are a number of couplers that

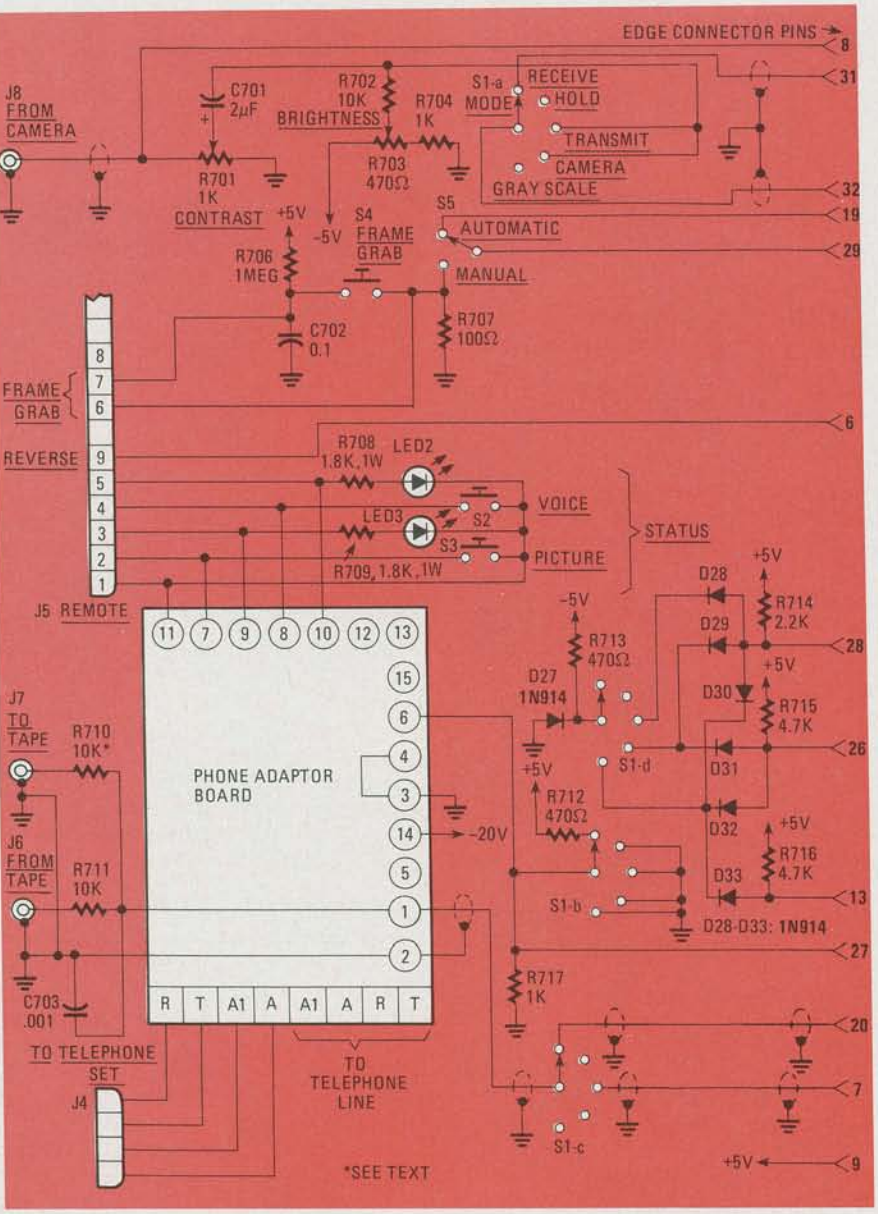


FIG. 16—WIRING DIAGRAM for chassis-mounted components and for connections to edge connector. Be especially careful in wiring diodes to S1-d.

FIG. 17—REAR PANEL of Picture Phone. Circuit-breaker reset is located above line cord at left.

will do the job for us available from various manufacturers; the one we'll use as an example is the Elgin Electronics model *EWP130A Voice Coupler,* which costs about $85 (see the Parts List for ordering information).

Figure 19 shows the terminals on the *EWP130A* board, and the connections that have to be made to the Picture Phone and the telephone company's modular telephone jack. Note that only the *tip* (green) and *ring* (red) leads are used.

The coupler is designed to pass audio signals and to translate the ring signal and on-hook/off-hook voltages into relay closures that will supply the appropriate voltages to the telephone equipment on your side of it. (You can do almost anything on *your* side of the coupler; that's why it's used—to protect the equipment on the telephone-company side from damage.)

The coupler requires two operating voltages and, if the telephone is going to be permanently connected to the Picture Phone, those voltages must *always* be available. Only a few hundred milliamps are required, and a suitable supply is shown in Fig. 20. It provides −24-volts DC to operate the coupler's relays, and 117-volts AC at 30 Hz (derived by placing diode D801 in the AC line) to ring the telephone's bell.

The coupler comes with a cord and modular plug, which is inserted in the wall jack that your phone would normally connect to (refer back to Fig. 19.) The telephone itself is connected to the modular jack on the rear of the Picture Phone and the user-side (your side) of the coupler to the "T" and "R" *output* terminals on the Picture Phone's telephone adapter board.

While the power supply for the coupler can be mounted inside the Picture Phone (and the 117-volts AC taken from its line cord *before* the power switch), the coupler should be mounted as close as possible to the wall jack it will be plugged into.

Be sure to notify your telephone company of the following:

1. The particular line to which you will be making your connection.
2. The type of jack used (type RJ11W in the case of modular wall jacks).
3. The FCC registration number of the coupler.
4. The ringer-equivalence number of the coupler.

Checkout and adjustment

Now that you know how to connect the Picture Phone to the phone line in a perfectly legal fashion, it's time to make sure that it works properly and to calibrate it. (If you run into problems, skip to the section on troubleshooting.) Perform the

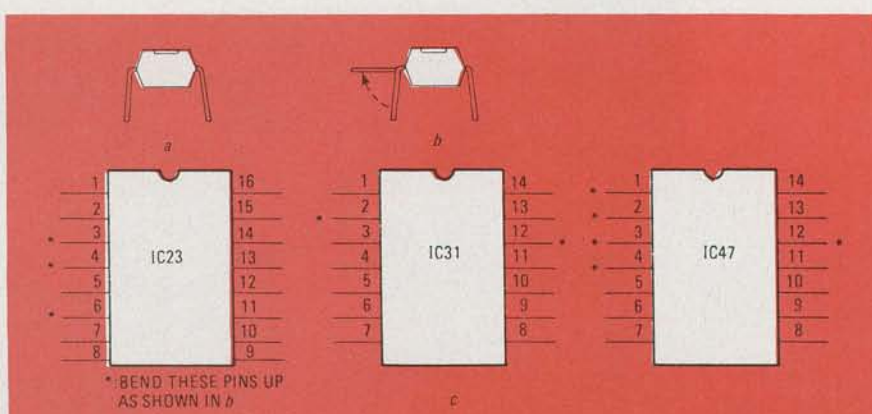


FIG. 18—SECTIONS OF IC23, IC31, and IC47 are disabled by bending IC pins up (*b*). Pins to be bent are indicated by asterisks in *c*.

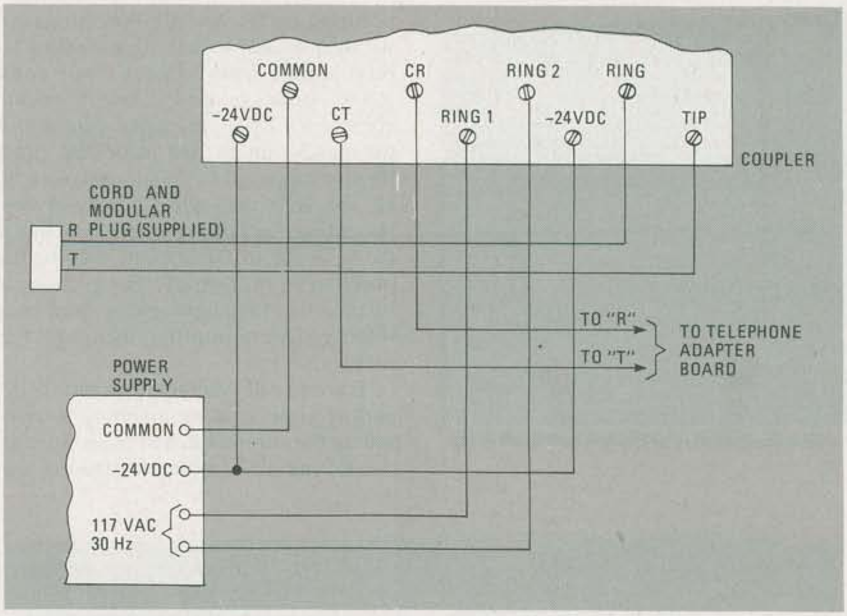


FIG. 19—CONNECTIONS TO AND FROM THE EWP130A coupler. Details of the power supply will be found in Fig. 21.

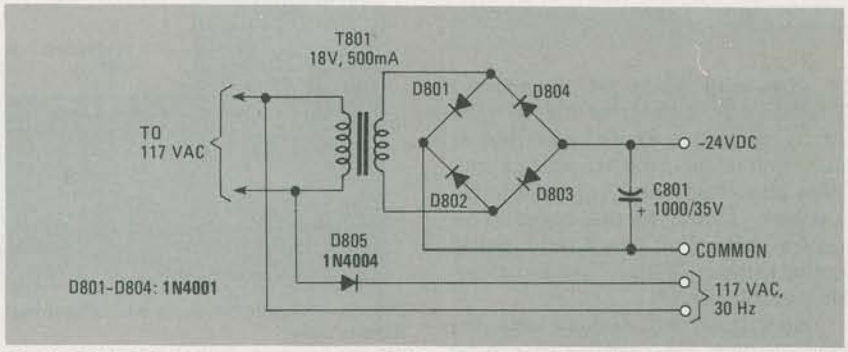


FIG. 20—POWER SUPPLY for use with the EWP130A telephone coupler. It can easily be built on perforated construction board and mounted inside the Picture Phone enclosure.

calibration *without* connecting the device to the phone line—if you leave it connected while you are working on it, anyone who tries to call you will get a busy signal. Instead, temporarily use a small piece of wire to jumper the contacts on the PICTURE switch so you are constantly in the VIDEO mode.

To perform the alignment you'll need a frequency counter, cassette recorder, and a video monitor or a TV set with an RF modulator (which you're going to need anyway when you put the Picture Phone to use). A TV camera, which, of course, you'll eventually require, is not needed for most of the alignment procedure.

The first step is to set the proper frequencies for slow-scan sync, white level, and black level. Connect a frequency counter to the TO TAPE jack and then temporarily connect TP2 (see Fig. 2 in the August issue) to +5 volts. Adjust the SYNC trimmer, R107 until you get a reading of 1200 Hz, the slow-scan sync frequency.

Next, ground TP2 and turn the front-panel CONTRAST control fully counterclockwise and the BRIGHTNESS control fully clockwise (Fig. 21 shows the front-panel controls). With the FRAME GRAB switch in the MANUAL position push the FRAME GRAB *button* to load a frame of white into memory. Adjust the WHITE trimmer potentiometer, R104, until you get a reading of 2300 Hz on your counter.

Finally, with TP2 still grounded, turn the CONTRAST control fully *clockwise,* and the BRIGHTNESS control fully *counterclockwise*. Adjust the BLACK trimmer, R106, until your counter reads 1500 Hz, the frequency used in slow scan to represent black. That completes the frequency adjustments for slow-scan output and you can remove the lead from TP2.

The next step is to adjust the brightness and contrast levels for slow-scan reception. That will be done by referring to the four-level (black, two shades of gray, and white) gray scale generated by the Picture Phone.

First, set the MODE switch to the GRAY SCALE position and snatch a gray scale using the FRAME GRAB button. **Do not be alarmed if, with no TV camera connected, you see a crazy jumble of lines on the screen in the GRAY SCALE or CAMERA mode. That is normal, and is due to the fact that the Picture Phone is receiving no fast-scan sync signal. The gray scale can be viewed by putting the MODE switch into the TRANSMIT or HOLD position.** You may notice some slight glitches where one gray shade meets the next. That, too, is normal, and will not be obvious when you are viewing slow-scan pictures.

With a gray scale being displayed from memory (MODE switch in the HOLD position) adjust the CONTRAST control of the monitor or receiver until the white bar at the right just begins to "bloom"—blend with the next shade of gray. Then adjust the monitor or TV set's BRIGHTNESS control until the black bar on the left matches the blanked area of the screen. Do not reduce the brightness below the point where the raster lines just disappear from the screen. Your display device should now be correctly adjusted for slow-scan viewing.

Now you can adjust the Picture Phone

FIG. 21—PICTURE PHONE'S front-panel controls. The FRAME GRAB button is below and to the left of the five-position MODE switch.

> **PICTURE PHONE DIRECTORY**
>
> Should you build—or purchase—your own Picture Phone, **Radio-Electronics** would like to know about it. We hope to publish a directory of Picture Phone users so, if you're interested in talking to (and seeing) others, be sure to include your telephone number.

for slow-scan reception. Connect a shielded audio cable from the TO TAPE jack of the Picture Phone to the line or mike input of the cassette recorder and, with a gray scale being displayed in the TRANSMIT mode, record about five-minutes worth. You may have to adjust the SINE trimmer, R204, to get an acceptable recording level.

Connect a second shielded cable between the output or earphone jack of the recorder and the FROM TAPE jack on the Picture Phone. Rewind the tape you just made and set the Picture Phone's MODE SWITCH TO THE RECEIVE position. Play back the gray-scale tape and adjust trimmers R138 (BLACK) and R141 (WHITE) until the recorded gray scale matches a frame-grabbed one (viewed in the TRANSMIT position).

If you are not able to make the recorded center two gray shades match the ones viewed directly from the Picture Phone, R138 is probably not set correctly. Change its setting slightly, and then try to match the two gray scales using R141. In the end, you should be able to make four distinctly different brightness levels.

The last two adjustments require a TV camera. A digitized, *real-time* image can be viewed with the MODE control in the CAMERA position. Focus on a round object—a dinner plate or fisbee, perhaps—and grab a frame of it. Use the SNATCH WIDTH trimmer, R56, to adjust the width of the picture stored in memory (viewed in the TRANSMIT or HOLD position of the MODE switch) until it is the same as that of the one obtained directly from the camera.

Finally, record several minutes worth of your test picture and then play it back with the MODE control in the RECEIVE position. Adjust the WIDTH trimmer, R143, until the picture just fills the square display area. It should have the same height and width as the picture viewed in the CAMERA mode.

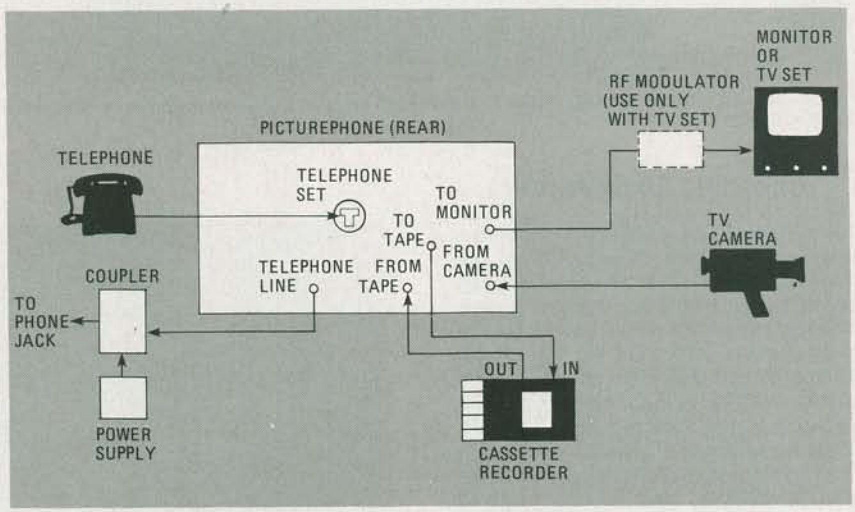


FIG. 22—CONNECTIONS TO AND FROM the Picture Phone. Be sure to use shielded cable to keep signals clean.

> **OOOOOOPS**
>
> In the schematic of the main board of the Picture Phone (Fig. 2, August 1982), capacitor C208 appeared twice. The C208 with a value of .001μF (near R139) should be omitted, as should its ground. In the Parts List (page 50, September 1982), resistor R81 *is* used—its value is 1000 ohms. Resistors R82—R84 are not used.

Remove the jumper from the PICTURE switch and you've completed the Picture Phone calibration, and are ready to put your unit to use.

Troubleshooting

The preceding assumed that your Picture Phone operated properly the first time you turned it on. It is quite possible—due to the complexity of the device—that it did not and the following may help you to set things right.

First, check for all the things you would normally look for if something you built didn't work. Check your solder joints—both on the PC boards and the chassis wiring— and make sure that all the wires run to and from the points they're supposed to. Also make sure that all the IC's and other polarized components are installed properly and that all the IC's are in the sockets they're supposed to be in. Don't forget to check for IC pins that may have gotten bent under when you were inserting them into their sockets.

You can tell whether your unit is outputting slow scan by grabbing a frame, setting the MODE switch to TRANSMIT, and connecting an earphone to the TO TAPE jack. You should hear a sort of burbling sound that's very difficult to describe in writing but which you'll soon become familiar with. If you hear a steady tone, something's wrong; start checking back from the slow-scan audio-output stage.

If everything you've built looks all right, but you're still not getting results, it's time to get an oscilloscope and start signal tracing. It's not enough to verify that all the clocking and control signals are present—they must also be at the proper logic-levels. In the unit I built, I found that an off-value resistor had caused the biasing of one of the 1458 op-amps to be off, and the logic-level signals it was passing were shifted to the extent that the following TTL IC's could not recognize them. Use a logic probe, if necessary, to verify that you are getting true logic-highs and logic-lows.

While IC's are normally the last things you should blame for your problems, brand-new ones do tend to have an "infant mortality" rate of about one percent and, in a device with as many IC's as the Picture Phone has, there is a chance that one of them is bad. So, if a signal goes into an IC but doesn't come out, try

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COMMUNICATIONS CORNER

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identification, time and date. Another key then transmits the calls and a personal identification from a preloaded buffer. A third key sends the message I composed on the screen—with all the errors corrected electronically (I can also transmit in real time, errors and all), and a fourth one sends the ending transmission, terminating with the usual NNNN.

If I want to dress up the basic communications system, an external file can be called up from a disk or tape for transmission. I can preload up to three programmed messages, initiate a local WRU (Who Are You) at the touch of a single key, single-key control a CQ string and...well, just about any of the drudgery can be eliminated by the computer. Essentially, the computer takes care of a lot of what we used to do when we had to prepare messages on punched tape, only now we don't have all of those little specks of yellow paper from the punch holes all over the floor.

My only complaint with computerized RTTY is that the software seems to have some sort of automatic slow transmission when the buffer is almost empty. There's an explanation for it in the documentation but it doesn't quite make sense to me. In any event, although it sometimes gets somewhat irritating to watch the letters crawl onto the screen, that's a relatively small price to pay for having the fun put back in RTTY. **R-E**

PICTURE PHONE

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replacing that IC. You may solve your problem as easily as that.

If you find that you have vertical "barber pole" stripes breaking up the picture that is stored in memory, check IC66, the 3245 memory driver; one of its sections may be bad. And, finally, if you find that a picture stored in memory starts to develop "freckles"—dark or bright pixels appearing one by one until the overall quality of the picture starts to deteriorate, try substituting standard 74157's in place of the "LS" versions for IC's 5, 21, 37, and 53.

That covers only a few of the many things that may keep your Picture Phone from working the first time you apply power, but, if you persevere, you'll locate the problem area(s) and wind up with a first-class device.

Setup

Figure 22 shows how the Picture Phone is to be connected to its associated equipment. Remember that the video output of the unit is intended for use with a monitor; if you use a TV receiver you'll need an RF modulator—those are readily available from most computer stores, or by mail from a number of advertisers in **Radio-Electronics.**

The most imporant factor in transmitting a good picture is good lighting; avoid hot spots and deep shadows. Try not to use a very light or very dark background—such a background may confuse the TV camera's ALC (*A*utomatic *L*ight *C*ontrol).

You can put the MODE switch in the CAMERA position to compose your picture, watching it on the monitor. The front panel BRIGHTNESS and CONTRAST controls will help give you the best-balanced image. To see what you will be transmitting, grab a frame from the camera and switch to the TRANSMIT or HOLD mode (you can grab a frame while in TRANSMIT).

Use

To use the Picture Phone, first place the phone call as you normally would to the other party. The Picture Phone can be on or off at this time, although you'll probably want it on so you can set up your pictures while you're talking. The until will come up in the VOICE mode when you apply power.

When you're ready to transmit slow-scan, grab a frame and inform the party at the other end of the line that you're ready to send video. Then turn the MODE switch to TRANSMIT and push the PICTURE button. That will disconnect the telephone handset from the line and connect in its place the output of the Picture Phone (you don't want your speech mixing with the slow-scan audio).

Every eight seconds you'll see the picture on your video display blink. That indicates that a frame has been completed. If you're in the MANUAL mode, the same frame will be repeated; if you're in the AUTOMATIC mode a new frame will be grabbed. The best time to switch back to VOICE mode is immediately after the finish of a frame. It's good practice to send more than one frame of each picture. Two are good; three may be better under some conditions.

When it's time for you to be on the receiving end, the other party will, of course, inform you that he or she is about to transmit video. Set the MODE switch to RECEIVE and press the PICTURE button. The slow-scan image will start forming from top to bottom, and will be complete in eight seconds. If you want to study a picture at leisure, use the HOLD position. If you do that, any further incoming video will be ignored, and you will be able to watch the same frame for as long as you like.

It may take a little practice to get the hang of using the Picture Phone, but, once you do, your personal and business telephone conversations will become tremendously richer. **R-E**